Comprehensive Fishery Survey of Crystal Lake, Dane County, Wisconsin 2015
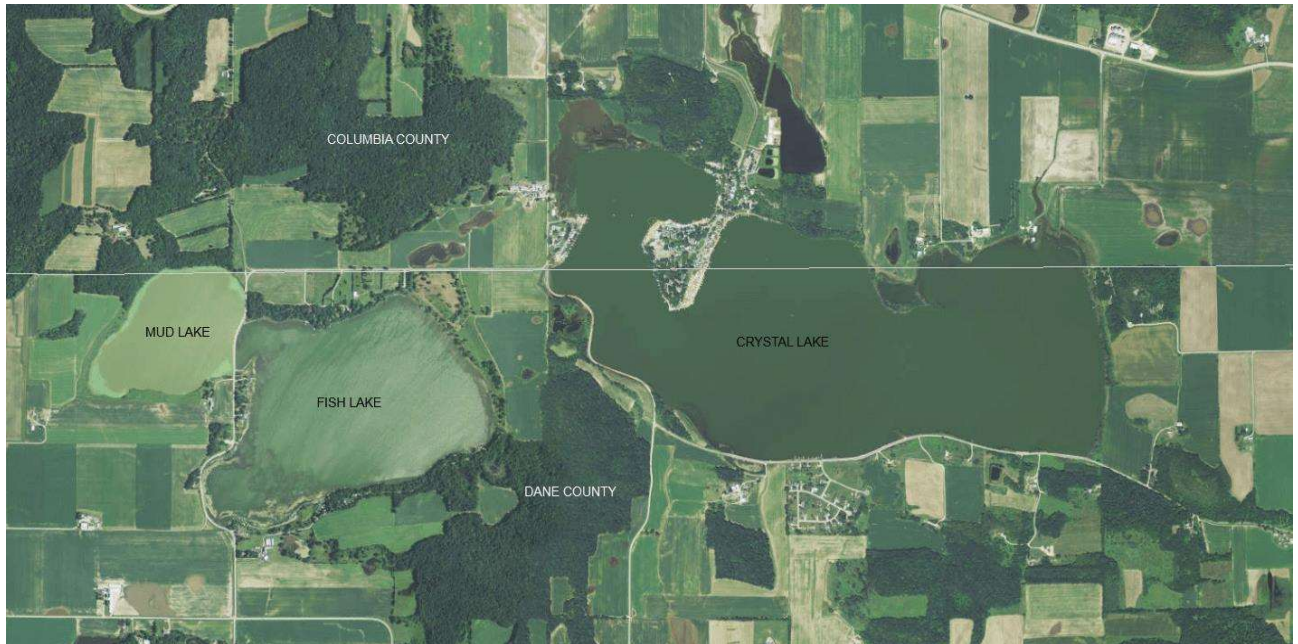
Waterbody Identification Code: 978900

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EXECUTIVE SUMMARY

A comprehensive fishery survey was conducted on Crystal Lake during the spring of 2015, including early fyke netting for northern pike (SN1), and two late spring electrofishing efforts for bass and panfish (SE2). Bluegill was the most abundant desirable sport fish species collected and the SE2 bluegill catch rate of 79.3fish/mile ranked in the 46th percentile statewide. Bluegills in Crystal Lake grow slightly faster than area and state averages, reaching 7.3 inches by age 5, 7.4 inches by age 6, and 8.2 inches by age 7. Mean length of age 4 and older bluegills have declined slightly from values observed in 1999 and 2005. Bluegill PSD, PSD-7, and PSD-P values calculated from SE2 were 78, 36, and zero, respectively. Values calculated from SN1 when the sampling gear is selective for larger bluegills were 71, 30, and 1, respectively. Total annual mortality for age 3 and older bluegills was 62%. Although Crystal Lake produces bluegills over 7 inches that are acceptable for harvest, relatively few fish over 8 inches are present; high end size structure is poor.

Black crappie was the second most abundant desirable species collected and the SN1 catch rate was 15.1 fish/net night. Growth is average; mean lengths at age are close to area and state averages throughout life. Black crappies average 8.3 inches at age 4, 9.0 inches at age 5, and 9.4 inches at age 6. The PSD, PSD-9, and PSD-P values calculated from the SN1 catch were 77, 17, and 1, respectively. Total annual mortality is 82% for ages 4 and older which is relatively high. Mean length at age has declined markedly for ages 3 and older from values observed in 1999 and 2005. A modest negative correlation between fish length and relative weight was observed; longer fish had lower relative weight values. White crappies were not noted in any surveys prior to 2015 and were present at far lower abundance than black crappies. Growth is above average; mean lengths at age were higher than area and state averages for ages 2 and older. White crappies averaged 9.3 inches at age 3, 9.9 inches at age 4, and 11.5 inches at age 5. White crappie recruitment is not consistent; ages 2 and 4 were the two dominant age classes while ages 1, 3, and 5 were insignificant.

Yellow perch was the third most abundant sport fish species collected. The fyke net catch rate was 11.6 fish/net night. Mean length at age has declined significantly for ages 3 and older since 1999. In 2015, female yellow perch averaged 7.9 inches at age 4, 8.4 inches at age 5, and 9.1 inches at age 6, while males averaged 7.4, 7.6, and 7.4 inches at ages 4 through 6. Total annual mortality was higher for females (88% for ages 5 and older) than for males (46% for ages 4 and older). The larger size of female perch likely contributes to elevated mortality levels due to higher harvest relative to males.

Largemouth bass are the dominant predator fish in Crystal Lake and are common but not abundant. The 2015 SE2 CPE8, CPE12, and CPE15 values of 22.1, 11.3, and 6.0 fish/mile ranked in the 38th, 66th, and 47th percentiles, respectively. The population of largemouth bass larger than 10 inches was estimated at 2.9 fish/acre in 2015, 19.8 fish/acre in 2005 and 35.7 fish/acre in 1999, representing a decline of 92% since 1999. Growth seemingly declined as well; mean length at age of age 4 and older largemouth bass was markedly lower in 2015 compared to 1999 and 2005. However, aging methods were changed after 2006 with dorsal spines replacing scales as the structure used, and this may help explain differences between 1999 and 2005 mean length at age compared to 2015. In 2015, largemouth bass reached legal harvest size as early as age 5 but did not average over 14 inches until age 8. The MAL14 value in 2015 was 7.5 years. Largemouth bass are much longer-lived in 2015 compared to 1999 and 2005 with the oldest fish in 2015 aged at 22 years, but again, the change in the structure used for age estimation may account for some of the differences observed. Total annual mortality was 19% for ages 4 and older in 2015 and this is relatively low. Body condition was good; relative weights averaged 102.

Northern pike are present at low abundance in Crystal Lake and this is consistent with previous surveys. Spawning habitat is a limiting factor, as is the lack of a cool water refuge during hot summers. The Schnabel population estimate for northern pike was 21 sexually mature fish, or less than 0.1 fish/acre. Fyke net CPE was 0.5 fish/net night, and lengths ranged from 19.6 to 34.3 inches, averaging 26.0 inches.

Other species including yellow bass, pumpkinseed, yellow bullhead, and brown bullhead are common in Crystal Lake and provide additional fishing opportunities for anglers.

The common carp SE2 observation rate was 39.3 fish/mile or 76.6 fish/hr. Using the Bajer-Sorensen population estimate method, the fish/hour catch rate translates to an estimated 86,895 carp, or 147.3 carp/acre.

Lake & location
Crystal Lake, Dane County (primary), Columbia County
T9N, R7E Sections 1, 2
T10N, R7E Section 35, 36

Physical/chemical attributes
Morphometry: 590 acres, maximum depth of 14 feet, 6.2 miles of shoreline.
Watershed: 3,697 acres (Krohelski et al. 2002).
Lake type: Seepage with no flowing inlet or outlet.
Water Clarity: Turbid
Trophic status: Hypereutrophic (Marshall et al. 2014)
Aquatic vegetation: Rare with low diversity. Two submersed and one emergent species found in 2012 point-intercept survey, and plants were only found at 4 out of 351 sample points (Jones et al. 2014)
Winterkill: Infrequent
Boat Landings: One public boat access point exists along the south shore of Crystal Lake on Crystal Lake Road, and is maintained by the WDNR. Shore fishing is available on most of the south shore along Crystal Lake Road.

Purpose of survey
Baseline lake survey Tier 1 assessment.

Dates of fieldwork
Fyke netting survey conducted March 24 through April 3, 2015 (SN1).
Electrofishing surveys conducted May 13, 2015 and May 28, 2015 (SE2).

Fishery
Bluegills, black crappies, yellow perch, and largemouth bass are common. Pumpkinseeds, white crappies, and northern pike are present. Fishing regulations for Crystal Lake can be found in Table 1.

BACKGROUND

Crystal Lake is a shallow seepage lake located mostly in northwestern Dane County with a small portion of the north side of the lake in located in southwestern Columbia County. The surface area has been recently reported as 525 acres (Marshall et al. 2014) but a digitized measurement on the 2013 aerial photo layer of the WDNR Surface Water Data Viewer places the surface area closer to 590 acres. The maximum depth of Crystal Lake is 14 feet, the lake does not thermally stratify, and the lake is considered hypereutrophic (Marshall et al. 2014). Crystal Lake, along with nearby Fish and Mud lakes, is connected to a common aquifer which has risen several feet over the last 70 years, causing the maximum depth of the lake to increase from 6 feet in the 1940s to 9 feet by 1960, and 14 feet at the present day (Krohelski et al. 2002, Marshall et al. 2014). From the 1940s to the 1960s, frequent winter fish kills were documented and aeration and stocking were used to keep the recreational fishery viable (Marshall et al. 2014).

In more recent years, water levels rose high enough to render the public boat access maintained by WDNR unusable for extended periods of time. Currently, water is pumped out of Crystal Lake and nearby Fish Lake to keep lake levels from rising enough to threaten nearby homes and infrastructure. By the spring of 2015, the pumping had reduced the level of Crystal Lake enough to allow the WDNR boat access to be used once again. Dane County Parks is undertaking land acquisition and development efforts with the goal of creating a new public access site to be located west of the WDNR access on the south shore of the lake.

The aquatic plant community in Crystal Lake has declined drastically in recent years. A 2006 point-intercept aquatic vegetation survey noted that overall aquatic macrophyte densities were low, 7 submersed species or groups were found, plants were found out to 13 feet water depth, and native aquatic plant species were dominant in Crystal Lake. Common waterweed (*Elodea canadensis*) and leafy pondweed (*Potamogeton foliosus*) were the two most abundant plants, followed by filamentous algae, Sago pondweed (*Stuckenia pectinata* or *Potamogeton pectinatus*), coontail (*Ceratophyllum demersum*), Eurasian watermilfoil (*Myriophyllum spicatum*), and curly-leaf pondweed (*Potamogeton crispus*) (Marshall et al. 2007). White water lily and cattails were also noted, and water clarity was poor with Secchi depths of 1.8 to 2.5 feet measured during the survey (Marshall et al. 2007). The 2007 report also noted that mechanical harvesting had not occurred since 1999 due to low densities of rooted aquatic plants and dense blue-green algal blooms (Marshall et al. 2007). A 2007 aquatic plant survey also found 7 submersed species, but the maximum water depth where plants were found had decreased to 5 feet. By contrast, a 2012

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point-intercept survey documented aquatic plants at 4 out of 351 sample sites (Jones et al. 2014). Only 2 submersed species, coontail and Eurasian watermilfoil, and one emergent species, common bur-reed (*Sparganium eurycarpum*) were found, and plants were found to a maximum depth of only 4 feet (Jones et al. 2014). High phosphorous concentrations contribute to blue-green algal blooms and summertime bottom anoxia contributes to significant internal nutrient loading (Marshall et al. 2014). Surrounding land use, particularly from row crops and feedlots, has contributed to phosphorous loading from external sources, although a reduction in croplands in the watershed between 1990 and 2010 led to an estimated 9% decrease in external phosphorous loading (Marshall et al. 2014). A failing wastewater treatment facility on the Columbia County side of the lake has also been identified as a source of significant nutrient loading (Marshall et al. 2014).

A 1985 electrofishing survey found black bullhead to be the most abundant species with golden shiners and fathead minnows relatively common as well (Unmuth and Larson 2000). However, few panfish and no largemouth bass were documented in the 1985 survey (Unmuth and Larson 2000). Rising water levels and increased water depths in Crystal Lake helped to alleviate winter kill issues and by the late 1980s the lake began to sustain viable largemouth bass and panfish populations. Growth rates for panfish species in Crystal Lake in the late 1990s were much faster than average statewide growth rates. In a 1999 WDNR fishery survey, bluegills averaged 8.2 inches at age 5, while black crappies averaged 10.1 inches at age 4, and yellow perch averaged 9.9 inches at age 4 (Unmuth and Larson 2000). Largemouth bass were abundant with an estimated population density of 35.7 fish/acre ≥ 10 inches, and largemouth bass averaged 14.5 inches by age 5 (Unmuth and Larson 2000).

Fast growth rates of panfish allowed Crystal Lake to build a reputation as a panfish factory and the fishery sustained itself despite high levels of angler effort and exploitation. Angler effort was estimated at 45,991 hours (87 hours/acre) from April 15 through June 30, 1999. The May-June effort of 42,927 hours nearly matched the total effort for the same period on 3,274-acre Lake Monona, and the April-June effort of 87 hours/acre approached year-round effort for Lake Mendota (94 hours/acre in 1993) and Lake Waubesa (98 hours/acre in 1995) (Unmuth and Larson 2000). The population of bluegills ≥ 5.5 inches was estimated during early spring fyke netting in 1999 using the Schnabel method. There were an estimated 183,611 bluegills, or 348 fish/acre. By 2005, largemouth population density had declined to 19.8 fish/acre ≥ 10 inches, but mean length at age of bass and panfish remained unchanged from 1999 estimates. Periodically,

columnaris infections cause spring fish die-off events, with the most recent documented event occurring in early June 2014 when black crappie was the most heavily impacted species. Unmuth and Larson (2000) also noted that columnaris-related die-offs occurred on a nearly annual basis.

Based on WDNR fishery survey data, yellow bass were introduced to Crystal Lake at some point between 1999 and 2002 when three yellow bass ranging from 8.5 to 10.0 inches were collected in a September electrofishing survey. Because of the lack of any type of surface water connection to other waters, yellow bass likely entered Crystal Lake via human introduction. The first documented reproduction of yellow bass was noted during a September 2004 electrofishing survey when two fish measuring 3.4 and 3.5 inches, respectively, were collected. Common carp entered Crystal Lake, although exactly when is unclear. None were noted in surveys in 1997, 1999, 2002, or 2003, but common carp were collected in a mini-fyke net survey in July 2004 and a fall electrofishing survey in September 2004. Common carp undoubtedly contribute to the turbid state of the lake and blue-green algal blooms through destabilization and re-suspension of bottom sediment, resultant losses of aquatic macrophytes, and the production of fecal matter.

Fish stockings have occurred infrequently in recent years. In 1973, 500 adult walleyes were stocked, but these fish did not establish a persistent population. Small fingerling largemouth bass were stocked in the late 1980s. Large fingerling yellow perch were purchased from a private hatchery by riparian owners and stocked in 2003 and 2004 after local anglers perceived a decline in the perch population. The recent stocking history for Crystal Lake can be found in Table 2.

METHODS

Data collection-spring netting and electrofishing

Following ice-out, four standard 3-foot frame fyke nets with 0.7-inch bar, 1.4 inch stretch mesh and two 4-foot frame fyke nets with 0.75-inch, 1.5 inch stretch mesh were set on March 24, 2015; these fyke nets targeted northern pike (SN1). One net was removed on March 28, one net was moved to a new location on March 30, and a second net was removed on March 31. Both nets that were removed had 3-foot frames. All remaining nets were run for the final time and pulled on April 3. Total netting effort was 51 net nights, and the GPS coordinates of the fyke net locations can be found in Table 3.

Gamefish and panfish were measured to the nearest 0.1 inch and a subsample of each species was weighed using electronic pan scales. Panfish and small gamefish were weighed on a scale with a capacity of 2 kilograms and a precision of 0.001 kg (1 gram). Larger gamefish were weighed on a scale with a capacity of 20 kg with a precision of 0.01 kg (10 grams). Both scales were manufactured by Yamato Corporation (model PPC-200W). Metric measurements were mathematically converted to pounds prior to data analysis. Aging structures were taken from a subsample of bluegills, black crappies, white crappies, largemouth bass, northern pike, and yellow perch (Table 4). The goal was to take structures from 5 fish per half-inch group for bluegills, both crappie species, and largemouth bass, and 5 structures per half-inch group from each sex for northern pike and yellow perch; sex was recorded when evident based on expression of eggs or milt. Mature northern pike captured during fyke netting were marked with a top caudal fin clip to calculating a population estimate, while immature fish were marked with a bottom caudal fin clip. All northern pike captured after the first lift day were examined for marks. Largemouth bass ≥ 8 inches were marked with a top caudal fin clip and those ≤ 8 inches were marked with a bottom caudal fin clip.

A WDNR standard direct current (DC) boom shocker boat was used to sample fish on Crystal Lake during the spring of 2015. The first electrofishing survey occurred on the night of May 13, 2015 (SE2). The second electrofishing survey occurred on May 28, 2015 (second SE2). On May 13, a total of two electrofishing stations were chosen. The first station began at a randomly selected start point, and was 2 miles in length. Panfish and gamefish were collected during the first 0.5 mile while gamefish only were collected for the remaining 1.5 miles. The second station included a 0.5 mile panfish segment, and the gamefish segment included the remainder of the shoreline of the lake (3.8 miles). Largemouth bass ≥ 8 inches were marked with a top caudal fin clip and those ≤ 8 inches were marked with a bottom caudal fin clip. Rough fish and other non-game fish were observed and counted while sampling the 0.5 mile panfish segments, but were not dip-netted. The second electrofishing survey (second SE2) occurred on May 28. The entire shoreline was sampled including a single 0.5 mile panfish segment with a randomly selected start point, which was added for collection of additional bluegill data. Gamefish only were collected over the remaining shoreline of the lake. Largemouth bass were examined for marks from the previous SE2 survey. Throughout both electrofishing surveys, all gamefish and panfish were measured to the nearest 0.1 inch. Aging structures were taken and weights were recorded from gamefish and panfish as necessary to fill out length bins. Starting and ending GPS coordinates for electrofishing stations can be found in Table 5.

<u>Data Analysis</u>

The largemouth bass PE (number of fish ≥ length x) was calculated using the Chapman modification of the Petersen single-census method where fish are marked during multiple fyke netting events and the first spring electrofishing event (SN2, SE2), followed by a single recapture event (second SE2 run). The formula is noted here:

$$N = \frac{(M+1)(C+1)}{R+1} - 1$$

Where N is the estimated population size, M is the number of fish that were marked, C is the number of fish captured on the recapture run and examined for marks, and R represents the number of fish captured on the recapture run that had marks. These estimates were calculated for several different size classes. Once the estimates were calculated, each was divided by the surface area of the lake to determine largemouth bass population density (number of fish ≥ length x / acre). This density was then compared to largemouth bass PEs calculated for Crystal Lake in 1999 and 2005.

A multiple census mark-recapture population estimate for northern pike was calculated using the Schnabel method. The formula for the Schnabel method is noted here:

$$N = \frac{\Sigma(C_t M_t)}{R+1}$$

Where N is the population size, C_t is the number captured on day t, M_t is the number marked on day t, and R is the total number of recaptures from the survey (Ricker 1975).

Recently, a study of carp populations in several small lakes in south-central Minnesota yielded a new, rapid method of estimating carp densities using electrofishing catch rates (Bajer and Sorensen 2012). The estimation equation from Bajer and Sorensen (2012) is noted here:

$$y = 4.71x + 3.04$$

Where y is the density of carp (fish/hectare), and x represents the electrofishing catch rate (fish/hr). Carp population density in Crystal Lake was estimated using this method with the number of catchable carp observed per hour during SE2 serving as the catch rate. The density of carp was then converted from a fish/hectare basis to a fish/acre basis. Bajer and Sorensen (2012) noted the potential for this method to be a highly effective tool at estimating carp abundance

when carp are present at moderate densities, but that it is slightly biased toward overestimating population size at low carp densities, and underestimating population size at high carp densities.

For SN1 and SE2, total catch and catch per unit of effort (CPE) were calculated by gear type for all species. Length frequency distributions were generated for panfish and gamefish species of interest, including bluegill, black crappie, white crappie, yellow perch, northern pike, and largemouth bass. Length range, mean length, median length, and mode length were calculated for all species. Proportional size distributions (PSDs) were calculated for all panfish and gamefish species with more than 100 stock-size individuals collected (Anderson and Neumann 1996, Guy et al. 2007). Length designations for stock, quality, legal or accepted harvest sizes, preferred, memorable, and trophy sizes of the panfish and gamefish species collected from Crystal Lake can be found in Table 6; these values were used for calculation of PSD (Anderson and Neumann 1996). For bluegills, separate PSD calculations were made from the fyke net catch and the SE2 catch. Possible bias toward larger fish exists for the fyke net data because fyke nets have been shown to be selective for larger bluegills (Laarman and Ryckman 1982).

Aging structures (scales, dorsal spines, and anal fin rays/spines) were used to estimate ages of a subsample of each species, and age and length data from these fish were used to generate age-length keys to estimate the age frequency of the whole population based on the aged subsample. Age frequency distributions were then generated for each species. The mean age at 14.0-14.9 inches (MAL14) is a metric used to compare growth in largemouth bass populations in Wisconsin, and this metric was calculated for largemouth bass from Crystal Lake and compared to the MAL14 values for several other lakes in Columbia, Sauk, and Dane counties.

Once age frequency distributions were completed for each species, inferences were made about year class strength and mortality when possible. Total annual mortality estimates were calculated using catch curves. Mean length at age was used to make inferences about growth of fish in Crystal Lake by comparing the lake to area and statewide averages. The area average was calculated from mean length at age values from lakes managed out of the Poynette Fisheries office and surveyed from 2006-2015 (11 lakes, 12 total surveys). Mean length at age was calculated using methods outlined in Bettoli and Miranda (2001), with the formula listed here:

$$\overline{Li} = (\sum N_{ij}\bar{l}_{ij})/N_i$$

Where $\overline{L}_i$ represents the mean length of the ith age group, $N_{ij} = N_j(\frac{n_{ij}}{n_j})$, N_j is the number of fish in the jth length group, n_{ij} = number of fish of the ith age group subsampled in the jth length group, n_j is the number of fish subsampled in the jth length group, and $N_i = \sum N_{ij}$ over all j length groups. The inputs to this equation are derived from the length frequency distribution of the sample and the age-length key. The midpoints of each length group were used for the values of $\overline{l}_{ij}$. This method extrapolates length at age data from the subsample of aged fish to the entire sample of fish collected (Bettoli and Miranda 2001). Simply reporting the mean length at age as the values calculated from the subsample of aged fish does not represent the entire sample because the subsampling is not in proportion to the frequency distribution of the sample (Bettoli and Miranda 2001).

Relative weights were calculated to evaluate body condition of fish. Relative weight (W_r) is a tool that compares the length of the fish to an expected weight for that length. Standard weights were calculated for individuals of each species that had weights recorded and standard weights were only calculated for individuals larger than the minimum recommended length for each species (Murphy et al. 1991, Anderson and Neumann 1996). Relative weights for each fish were calculated by dividing a fish's actual weight by the standard weight for a fish of that length. Average relative weight was then calculated for each species, and was done for each sex separately when sex data were available. Relative weight values between 75 and 100 indicate normal weight for a given length. A relative weight value greater than 100 indicates that a fish is in excellent condition. A relative weight value less than 75 indicates that a fish is in poor condition.

RESULTS AND DISCUSSION

General Fish Community

A total of 6,390 fish representing 14 different species from 6 families was sampled during spring netting and electrofishing on Crystal Lake in 2015. Catch by gear type is shown for each species collected in Table 7.

<u>Bluegill</u>

In total, 3,353 bluegills were collected during the spring; the catch rates were 63.4 fish/net night during SN1 and 79.3 fish/mile of shoreline during SE2 (Table 7). The SE2 catch rate ranked in the 45th percentile statewide; bluegills are common in Crystal Lake. In terms of the total number of fish caught during spring netting and electrofishing, bluegill was the most abundant species collected (Table 7).

In total, 2,638 bluegills collected during SN1 and 119 collected during SE2 were measured. Aging structures were taken from a subsample of 54 fish and weights were recorded from a total of 53 fish. Bluegills captured during SN1 ranged from 3.0 to 8.4 inches in length and the mean and median values were 6.3 and 6.5 inches, respectively. The PSD, PSD-7, and PSD-P values calculated from SN1 were 71, 30, and 1, respectively (Table 8). Bluegills captured during SE2 ranged from 3.4 to 7.6 inches in length and the mean and median values were 6.4 and 6.7 inches, respectively. The PSD, PSD-7, and PSD-P values calculated from SE2 were 78, 36, and zero, respectively (Table 8). Length frequency distributions of bluegills caught during SN1 and SE2 are represented in Figures 1 and 2, respectively. Higher PSD and PSD-7 values during SE2 compared to SN1 does not support the hypothesis that fyke nets are selective for larger bluegills, and is the opposite of what is generally observed in spring fishery surveys in Columbia and Sauk counties. Bluegills larger than 7 inches are often acceptable for anglers to harvest and are present in Crystal Lake. Larger bluegills are rare however, as evidenced by the low PSD-P values for both the SN1 and SE2 catch.

Bluegill ages ranged from 2 to 8 years in 2015, with age 3 fish being the most common in the distribution (36%), followed by age 5 (21%) and age 4 (20%) (Figure 3). Bluegill growth in Crystal Lake (mean length at age) is at or slightly above the area average, and comfortably above the state average for ages 2 through 8 (Figure 4). Bluegills in Crystal Lake average 6.1 inches by age 3, 7.3 inches by age 5, and 8.2 inches by age 7 (Figure 4). By contrast, in 1999 bluegills in Crystal Lake averaged 8.2 inches by age 5, but by 2005 mean length at age 5 had declined to 7.6 inches (Figure 5). Bluegill mean length at ages 2 and 3 was higher in 2015 than in 1999 and 2005 (Figure 5). However, mean length at ages 4 and older appears to have declined steadily from 1999 to 2015 (Figure 5). Total annual mortality for ages 3 through 8 was 62% in 2015 (Table 9, Figure 6). Overall, bluegills larger than 3 inches were in good condition; mean relative

weight was 97.4 (Figure 7). There was no discernable positive or negative relationship between fish length and relative weight.

Black Crappie

In total, 776 black crappies were collected during the spring; the catch rates were 15.1 fish/net night during SN1 and 4.7 fish/mile of shoreline during SE2 (Table 7). The SE2 catch rate ranked in the 34th percentile statewide; black crappies are common in Crystal Lake. However, black crappies are rarely captured in significant numbers during SE2 surveys relative to the number captured during fyke net surveys, and spring electrofishing catch rates may not be the best estimator of black crappie abundance. In terms of the total number of fish caught during the survey, black crappie was the second most abundant species collected (Table 7).

In total, 756 black crappies collected during SN1 and 7 collected during SE2 were measured. Aging structures were taken from a subsample of 55 fish and weights were recorded from a total of 53 fish. Black crappies captured during SN1 ranged from 3.6 to 10.6 inches in length and the mean and median values were 8.3 and 8.4 inches, respectively. The PSD, PSD-9, and PSD-P values calculated from SN1 were 77, 17, and 1, respectively (Table 8). Black crappies captured during SE2 ranged from 8.4 to 9.5 inches in length and the mean value was 8.8 inches. The length frequency distributions for black crappies captured during SN1 is represented in Figure 8.

Black crappie ages ranged from 1 to 7 years, with age 4 fish being the most common in the distribution (57%), followed by age 5 (20%) and age 2 (8%) (Figure 9). Black crappies were fully vulnerable to the sampling gear by age 4, and total annual mortality was high (82%) for ages 4 through 7 (Table 9, Figure 10). Black crappie mean length at age in Crystal Lake is very similar to area and state averages for all ages in the sample (Figure 11). Black crappies averaged 7.5 inches at age 3, 8.3 inches at age 4, and 9.0 inches at age 5 (Figure 11). Mean length at age of black crappies was similar in 1999 and 2005 but appears to have declined from 2005 to 2015, and the difference is greater for older fish (Figure 12). Overall, black crappies larger than 4 inches were in good condition (mean relative weight = 97.2, Figure 13). However, there was a weak negative correlation between crappie length and relative weight; longer crappies had lower relative weights. This may indicate a lack of sufficient forage to sustain crappie growth and body condition at larger sizes.

Yellow Perch

In total, 601 yellow perch were collected during the spring; the catch rates were 11.6 fish/net night during SN1 and 7.3 fish/mile of shoreline during SE2 (Table 7). In terms of the total number of fish caught during spring netting and electrofishing, yellow perch was the third most abundant species collected (Table 7).

In total, 590 yellow perch collected during SN1 and 11 collected during SE2 were measured. Aging structures were taken from a subsample of 72 fish and weights were recorded from a total of 71 fish. Four hundred ninety-one male yellow perch captured during SN1 ranged from 5.3 to 8.9 inches in length and the mean and median values were 7.4 and 7.3 inches, respectively (Table 8). Ninety-nine female yellow perch captured during SN1 ranged from 5.8 to 9.8 inches in length and the mean and median values were 8.3 and 8.4 inches, respectively (Table 8). For all yellow perch captured during SN1 regardless of sex, the average and median lengths were 7.4 and 7.5 inches, respectively. Overall PSD, PSD-9, and PSD-P values for all yellow perch were 23, 3, and zero, respectively (Table 8). Eleven yellow perch captured during SE2 ranged from 3.1 to 6.8 inches in length and the mean length was 4.5 inches (Table 8). The length frequency distributions for yellow perch captured during SN1 are represented in Figure 14.

Age 1 yellow perch were not present in the sample. Age 2 fish were almost entirely absent as well, and this is most likely due to them being immature, not engaged in spawning behavior, and thus not vulnerable to the sampling gear. Also, nearly all the yellow perch collected were caught in fyke nets and age 1 and most age 2 fish are likely too small to be contained by the fyke net mesh used in the survey. Yellow perch ages ranged from 2 to 9 years and no age 8 fish were captured for either sex (Figure 15). When considered together (sexes combined) age 4 was the most common in the distribution (41%) indicating that yellow perch were fully vulnerable to the sampling gear by age 4, followed by age 5 (33%) and age 3 (14%). Total annual mortality for ages 4 to 8+ was 69% (Table 9, Figure 16). Yellow perch mean length at age was at or below state averages throughout life. Yellow perch averaged 7.4 inches at age 4, 7.8 inches at age 5, and 8.2 inches at age 6 (Figure 17). Mean length of age 7 perch (8.0 inches) was most likely lower than age 6 because all age 7 fish captured were males. Yellow perch growth in Crystal Lake has declined substantially since 1999 when yellow perch averaged 8.0 inches at age 4, 9.9 inches at age 5, and 11.4 inches at age 6 (Figure 18).

When considering sexes separately, it is apparent that female yellow perch grow faster and attain larger sizes over their lifetime than males. The length frequency distribution for yellow perch separated by sex is represented in Figure 19. Ages of female yellow perch ranged from 3 to 9 years (Figure 20). Age 5 females were the most common (66%) indicating that female yellow perch were fully vulnerable to the sampling gear by age 5, followed by age 4 (16%), and age 6 (12%). Total annual mortality was very high at 88% for females aged 5 to 7+ (Table 9, Figure 21). Females averaged 7.9 inches at age 4, 8.4 inches at age 5, and 9.1 inches at age 6 (Figure 22). The single age 9 female measured 9.7 inches.

Ages of male yellow perch ranged from 2 to 7 years for (Figure 20). Age 4 males were the most common (48%) indicating that male yellow perch were fully vulnerable to the sampling gear by age 4, followed by age 5 (20%), and age 3 (16%). There were more age 7 fish (10%) than age 6 fish (4%) in the distribution, and this may be indicative of a better than average year class of yellow perch in produced in 2008, or a below average year class in 2009. Total annual mortality for males aged 4 to 7 was 46% (Table 9, Figure 23). This value was far lower compared to age 5 to 8+ females (88%). Males averaged 7.4 inches at age 4, 7.6 inches at age 5, and 7.4 inches at age 6 (Figure 24). Of the sample of aged fish, only three males were aged at 6 years, and length values for two of these fish were relatively low, which accounts for the lower mean length at age 6 compared to age 5.

Yellow perch appeared to be in good condition based on relative weight values. Relative weights of 33 male yellow perch averaged 95.6 and 38 females averaged 106.8. Relative weight values for females were likely elevated due to these fish being in spawning condition. Only two fish had a relative weight below 75 indicating poor body condition (Figure 25).

Largemouth bass

In total, 355 largemouth bass were collected during the spring including recaptures; overall catch rates were 1.1 fish/net night during fyke netting and 28.2 fish/mile of shoreline during two SE2 sampling events (Table 7). Largemouth bass was the fourth most abundant sport fish species sampled during the survey. A total of 186 largemouth bass ≥ 10 inches was marked for the population estimate during fyke netting and the first SE2 run (M). In total, 109 fish ≥ 10 inches were captured on the second SE2 run (C), and 11 of these were found to have marks (R). The

population estimate (PE) of the number of largemouth bass ≥ 10 inches in Crystal Lake was 1,713 fish, or 2.9 fish/acre (95% CI 1,033- 3,111 total, or 1.8 - 5.3 fish/acre).

The catch rate of fish ≥ 8 inches (stock size) during SE2 was 22.1 fish/mile. This value ranked in the 38th percentile in a comparison of four southern Wisconsin drainage basins. The catch rate of fish ≥ 12 inches during SE2 was 11.3 fish/mile and this value ranked in the 66th percentile in a comparison of lakes statewide. The catch rate of fish ≥ 15 inches during SE2 was 6.0 fish/mile and this value ranked in the 47th percentile in a comparison of lakes statewide. These values indicate that overall bass densities are moderate, and the number of larger bass in Crystal Lake is near the middle of the pack when compared to other lakes around the state.

In total, 285 largemouth bass collected during SN1 and 56 collected during SE2 were measured (totals exclude recaptures). Aging structures were taken from a subsample of 139 fish and weights were recorded from a total of 136 fish. Largemouth bass captured during SN1 ranged from 5.5 to 22.1 inches in length and the mean and median values were 12.8 and 11.8 inches, respectively (Table 8). Largemouth bass captured during SE2 ranged from 4.4 to 20.8 inches in length and the mean and median values were 12.7 and 11.8 inches, respectively (Table 8). The PSD, PSD-14, PSD-P, and PSD-18 values calculated from SE2 were 50, 33, 26, and 8, respectively (Table 8). The PSD, PSD-14, and PSD-18 values rank in the 30th (statewide), 62nd (statewide lakes < 794 acres), and 39th (statewide) percentiles, respectively. The length frequency distribution for largemouth bass is represented in Figure 26.

In total, ages were estimated for 137 largemouth bass. Largemouth bass ages ranged from 1 to 22 years in 2015, with age 4 fish being the most common in the distribution (20%), followed by age 3 (18%) and age 5 (16%) (Figure 27). Total annual mortality for ages 4 through 22 was 19% in 2015 (Table 9, Figure 28). By contrast, total annual mortality was 78% for ages 4 through 8 (the oldest fish in the distribution) in 1999. However, differences in aging methodology prior to 2006 (scales used instead of dorsal spines) limit the value of 1999 and 2005 largemouth bass age and growth data for comparison to 2015 estimates. Largemouth bass growth in Crystal Lake (mean length at age) is similar to area and state averages through age 4 and is lower than these averages for ages 5 and older (Figure 29). Largemouth bass in Crystal Lake reach the minimum harvest size of 14 inches as early as age 5, and average over 14 inches by age 8 (Figure 29). By contrast, in 1999 largemouth bass in Crystal Lake reached legal harvest size as early as age 4 and averaged over 14 inches by age 5. The MAL14 value was 7.5 years in 2015 (Table 10). Largemouth bass

mean length at age for ages 1 through 3 in 2015 was nearly identical to both 1999 and 2005, but was lower for ages 4 and older and the difference between 2015 and the two prior sample years increased with age (Figure 30).

Overall, largemouth bass larger than 6 inches were in good condition; mean relative weight for 136 weighed largemouth bass was 102. There was no discernable positive or negative relationship between fish length and relative weight. No fish had a relative weight below 75, and 56% of weighed fish (76 out of 136) had relative weights greater than 100. Relative weights for largemouth bass in Crystal Lake are represented in Figure 31.

White Crappie

In total, 68 white crappies were collected during the spring; the catch rates were 1.3 fish/net night during SN1 and 0.7 fish/mile of shoreline during SE2 (Table 7). In terms of the total number of fish caught during spring netting and electrofishing, white crappie was the eleventh most abundant species collected (Table 7).

In total, 67 white crappies collected during SN1 and one collected during SE2 were measured. Aging structures were taken from a subsample of 46 fish and weights were recorded from a total of 43 fish. White crappies captured during SN1 ranged from 3.7 to 11.6 inches in length and the mean and median length values were 8.5 and 8.3 inches, respectively (Table 8). The single white crappie captured during SE2 measured 7.7 inches. The length frequency distribution for white crappies captured during SN1 is represented in Figure 32.

Ages ranged from 1 to 5 years, with age 2 fish being the most common in the distribution (49%), followed by age 4 (35%) and age 3 (9%) (Figure 33). Recruitment appears to be inconsistent based on the large number of age 2 and age 4 fish relative to other ages in the sample. These year classes were produced in 2013 and 2011. White crappie growth in Crystal Lake is very similar to region average length at age for all ages in the sample except age 1, which is lower than both area and state averages (Figure 34). White crappies averaged 7.9 inches at age 2, 9.3 inches at age 3, and 9.9 inches at age 4 (Figure 34). There are no white crappie data from previous surveys for comparison to 2015; this survey represents the first record of white crappies in Crystal Lake. Overall, white crappies larger than 4 inches were in good condition (mean relative weight = 98.8, Figure 35). However, there was a weak negative correlation between white crappie length and

relative weight; longer crappies had lower relative weights. This relationship was also seen in black crappies in Crystal Lake, and may indicate a lack of sufficient forage to sustain crappie growth and body condition at larger sizes.

Northern Pike

In total, 26 northern pike were sampled during SN1 (including recaptures); the catch rate was 1.3 fish/net night (Table 7). The total catch excluding recaptures was 18 fish and the Schnabel population estimate was 21 sexually mature northern pike, or less than 0.1 fish/acre (95% CI 12 - 36 total, or 0.0 - 0.1 fish/acre).

Overall, 18 northern pike collected in fyke nets (total excluding recaptures) ranged from 19.6 to 34.3 inches, averaging 26.0 inches (Table 8). The sex ratio for known-sex fish was 2.6:1.0, males to females. Thirteen male northern pike ranged from 19.6 to 26.0 inches, averaging 23.6 inches. Five female northern pike ranged from 29.9 to 34.3 inches, averaging 30.9 inches.

Overall, northern pike ages ranged from 4 to 11 years. Thirteen males ranged from 4 to 11 years and one fish, a 26-inch age 7 male, was large enough to be legally harvested. Four age 6 females averaged 32.9 inches and a single age 8 female measured 29.9 inches; all were larger than the minimum length limit. Too few individuals were collected to produce meaningful length and age frequency charts, so date of capture, sex, length, weight, and age data for each fish are listed individually in Table 11.

Condition of northern pike was average. Relative weights for northern pike were generally lower for males which averaged 92.0, while females averaged 112.0 and all northern pike regardless of sex averaged 97.0. No fish had a relative weight below 75 which would indicate poor body condition. Females had substantially higher relative weights than males because they were in spawning condition (full of eggs). Relative weights for northern pike are represented in Figure 36.

Other Fish Species of Interest

Yellow bullheads are common in Crystal Lake, and 324 were collected during the survey. In total, 265 yellow bullheads were measured and lengths ranged from 4.8 to 12.3 inches, averaging

9.6 inches. Brown bullheads are also common; 166 brown bullheads were measured and lengths ranged from 5.7 to 13.3 inches, averaging 11.0 inches. Pumpkinseeds were common; a total of 252 ranged from 2.0 to 6.7 inches, averaging 5.5 inches. An 18-inch sauger was collected in a fyke net on April 1, 2015. This fish would have been intentionally (and illegally) introduced to Crystal Lake by humans and would have been transported to Crystal Lake from the nearby Wisconsin River.

Undesirable Species

Common carp is a detrimental rough fish species that often negatively impacts water quality. Seventeen common carp were collected in fyke nets during SN1. The carp ranged from 8.5 to 27.3 inches in length, averaging 22.5 inches. During spring electrofishing, 59 common carp were counted while sampling panfish stations, for an observation rate of 39.3 fish/mile or 76.6 fish/hr. The Bajer-Sorensen estimation equation yielded a carp density of 363.9 fish/hectare, or 147.3 fish/acre, for an estimated total population of 86,895 carp.

Yellow bass are a gamefish but may be viewed as an undesirable species, particularly when present at high abundance. A total of 244 yellow bass was collected during SE2, and the catch rate was 162.7 fish/mile (316.9 fish/hr.). The first survey record of yellow bass in Crystal Lake dates to a fall electrofishing survey in 2002. The first documented recruitment of young fish occurred in 2004. In 2015, yellow bass ranged from 3.0 to 10.1 inches in length, averaging 7.1 inches. The yellow bass length frequency distribution is represented in Figure 37, and there are three size groups in the distribution. The first size group covers the 3.0 through 4.5 half-inch groups, the second covers the 6.0 through 7.5 half-inch groups, and the third covers the 8.0 through 10.0 half-inch groups. Based on yellow bass length-at-age data presented in works by Priegel (1975) from a study of Lake Poygan, Wisconsin, and Katzenmeyer (2010) from a study of Clear Lake, Iowa, these size groups likely correspond to age 1, age 2, and ages 3-4, respectively.

CONCLUSIONS AND RECOMMENDATIONS

Panfish provide the bulk of the fishing opportunities for anglers in Crystal Lake, and provide a vital food resource for gamefish. Bluegills are common but recent historical catch rate data for temporal comparisons of bluegill abundance is lacking. Much of the electrofishing effort on Crystal Lake prior to 2015 was invested in monitoring the largemouth bass population and

bluegill data were often not collected. An electrofishing survey in September 2004 yielded a bluegill CPE of 91 fish/mile (one mile of effort; two half-mile panfish stations).   A fyke net survey in late March and early April of 1999 captured 1,051 bluegills for a catch rate of 23.4 fish/net night.   By contrast the spring 2015 survey yielded a lower electrofishing catch rate (79.3 fish/mile), but a higher fyke net catch rate (63.4 fish/net night). Meaningful conclusions on changes in abundance cannot be drawn from these data. However, age and growth data indicate bluegill mean length at age has declined from values observed in 1999 and 2005 for ages 4 through 6. When comparing population size structure in the early spring fyke net surveys in 1999 and 2015, PSD and PSD-P values are similar (69 and 3 vs. 71 and 1), while the PSD-7 value in 2015 (30) was more than double what was observed in 1999 (14). The maximum size of bluegills collected in surveys has declined over time. The largest fish collected in the 1999 fyke net survey was 9.6 inches, the largest in a June 2005 fyke net survey was 9.4 inches, and the largest collected in 2015 (all gear types) was 8.4 inches.

Total annual mortality for ages 3 through 8 was 62% in 2015. A previous study of 13 lakes with low-level exploitation in the Nebraska Sand Hills yielded a mean total annual mortality estimate of 30.9% and the authors felt exploitation was low enough that this value would be analogous to natural mortality estimates in other Midwestern bluegill populations (Paukert et al. 2001). Similarly, a study of an unexploited lake in central Wisconsin yielded an annual mortality estimate of 30% over a three-year period prior to the lake being opened to fishing (baseline natural mortality, Goedde and Coble 1981). In an exploited fishery such as Crystal Lake, however, fishing mortality is likely much higher than zero, and the increase in mortality due to fishing is most likely compensated for by a reduction in the natural mortality rate. Therefore, simply subtracting a baseline natural mortality rate of 30% from total mortality leaving 32% of mortality attributed fishing is incorrect.   Unmuth and Larson (2000) estimated bluegill exploitation in Crystal Lake at 33% based on the estimated number of marked fish harvested by anglers compared to the number of fish marked during the survey. However, angler harvest data were not collected as part of the 2015 survey and a current estimation of exploitation is not possible.

The management goal for Crystal Lake is to maintain a balanced bluegill population that provides forage for predator fish while still providing anglers the opportunity to harvest fish. The objectives are SE2 CPE ≥ 100 fish/mile with a PSD between 20 and 60, an PSD-7 value ≥ 10, and an PSD-P value ≥ 5. Currently, only the PSD-7 objective is being met. The SE2 CPE value is

low, the PSD value is well above the recommended range, and the PSD-P value is low. It is recommended that these metrics continue to be monitored through the baseline lake survey rotation. No regulation change is currently recommended.

Little in the way of substantial black crappie data were collected from Crystal Lake prior to 2015. An early spring fyke net survey in late March and early April of 1999 yielded only 65 fish for a CPE of 1.4 fish/net night. The catch rate of 15.1 fish/net night in 2015 was over 10 times higher, and may indicate greater abundance, but may also be an artifact of net locations and water temperatures during the sampling period.   However, black crappie mean length at ages 3 and older declined markedly from levels observed in 1999 and 2005, which supports the idea that abundance increased substantially. Additionally, differences in mean length-at-age between the time periods are larger for older fish. Mean length at age 4 was nearly 2 inches less in 2015 (8.3 inches) than in 1999 and 2005 (10.1 and 10.2 inches, respectively). Mean length at age was relatively close to area and state averages for all ages in the 2015 sample.

Total annual mortality of black crappies was 82% for ages 4 and older. A study of several lakes in the Nebraska Sand Hills with low exploitation yielded a mean annual mortality estimate of 38.6% for black crappies, which the authors felt was essentially analogous to natural mortality (Paukert et al. 2001). In an exploited fishery like Crystal Lake, fishing mortality likely makes up a larger portion of total annual mortality, and natural mortality is correspondingly less than the approximately 40% that it would be in an unexploited fishery. Relative weight was weakly correlated with fish length; longer black crappies had lower relative weight values, and this may be indicative of a lack of suitable forage to sustain black crappie growth and body condition at older ages. Reduced water clarity in recent years may make it difficult for larger crappies to forage for prey fish, coupling with increases in abundance to lead to slower growth and lower relative weights.

White crappies were not noted in any WDNR fishery surveys of Crystal Lake prior to 2015. Crystal Lake does not have any surface water connection to other waterways; white crappies could not have come naturally from a connected water with a source population so therefore were introduced by humans. This is certainly plausible considering the number of other species present in 2015 that did not historically occur in Crystal Lake and their likely means of introduction. White crappie recruitment is inconsistent and they grow faster, attain larger sizes, and have shorter life spans than black crappies in Crystal Lake. Like black crappies, white

crappie relative weight was weakly correlated with fish length; longer white crappies had lower relative weight values, and this may be indicative of a lack of suitable forage to sustain growth and body condition at older ages.

The management goal for black crappies is to maintain a population that provides forage for predator fish while still providing anglers the opportunity to harvest fish. The size-structure objective is a PSD-9 value ≥ 15. Currently, this objective is being met. It is recommended that abundance, growth, PSD, and mortality metrics continue to be monitored through the baseline lake survey rotation. Under current protocols, the SN1 sampling period offers the best chance to collect large amounts of black crappie data. No regulation change is currently recommended.

Northern pike are present at low abundance in Crystal Lake and this has been the case historically. A fyke net survey in late March and early April of 1999 captured only 3 northern pike for a catch rate of 0.1 fish/net night. The fyke net catch rate in 2015 was slightly higher at 0.5 fish/net night. A combination of low adult numbers and a relative lack of spawning habitat is the cause of the small population size. Shallow depths and resultant lack of a cool water refuge for northern pike during periods of high water temperatures in summer may also negatively impact the population. If the water level in Crystal Lake is lowered and emergent vegetation can re-colonize parts of the littoral zone, increased natural production may occur, but the northern pike population is likely to remain at very low levels unless supplemental stocking efforts occur. Due to the minor importance of the fishery historically and currently, there are no specific management goals or objectives for northern pike and no regulation changes are needed. Because of the lack of a cool water summer refuge, stocking of northern pike as a means of increasing the predator density in the lake is not recommended.

Largemouth bass in Crystal Lake are moderate in abundance and size structure is near the middle of the pack compared to other largemouth bass populations in small Wisconsin Lakes. However, largemouth bass abundance in Crystal Lake has declined substantially since 1999 despite marked reductions in the mortality rate. Unmuth and Larson (2000) estimated exploitation of largemouth bass to be 31%, whereas total annual mortality after age 4 was only 19% in 2015. Largemouth bass population density (fish/acre ≥ 10 inches) declined by 92% from 1999 (35.7 fish/acre) through 2015 (2.9 fish/acre, Figure 38). Largemouth bass electrofishing CPE<8, CPE8, CPE10, and CPE12 values have also all showed serious declines from 1999 through 2015 (Figure 39). The number of larger, legally harvestable bass has generally increased since 1999 based on

CPE15, CPE18, and CPE 20 values, although CPE14 values were slightly lower in 2015 than in 1999, following an upward spike in 2003 (Figure 40). Despite an overall decline in PSD, the proportion of the population composed of larger bass has increased since 1999 based on PSD-14, PSD-P, and PSD-18 values (Figure 41). The maximum age of largemouth bass in Crystal Lake has increased from 8 years in 1999 to 22 years in 2015. Mean length at age after age 3 is lower in 2015 compared to both 1999 and 2005 and the difference increases with age.

In summary, the largemouth bass population in Crystal Lake appears to have transitioned from a high density, fast growing, short-lived population to a low-density, slower growing, and longer-lived population with more large, old bass. Serious reductions in the catch rates of fish smaller than 8 inches after 1999 might suggest that the decline in bass abundance has been driven by reduced recruitment rather than harvest of adults. Reductions in recruitment may be at least in part a compensatory response to increased survival and abundance of large bass.
The value of comparisons of 2015 age and growth data to 1999 and 2005 may be limited due to differences in aging methods between the time periods. Scales were used for bass age estimation in the Poynette field office prior to 2006, and dorsal spines have been used since that time. Dorsal spines yield more precise age estimates for largemouth bass compared to scales, and scales tend to under estimate ages after age 8 (Morehouse et al. 2013).

With such a serious reduction in bass population density, it might be expected that growth rates would improve, but the opposite appears to have happened. One hypothesis for this is that reductions in water clarity attributed to increased nutrient inputs and sediment disturbance caused by common carp have had a detrimental effect on the ability of largemouth bass, a sight feeding predator, to forage for prey. However, body condition remains good and if foraging conditions were truly poor, then poorer body condition would be expected. Perhaps a better explanation is that the change in aging methods has improved the precision and accuracy of age estimation, and that fish aged from scales during a prior era were older than estimated and growth during that era was not as good as it first appeared. Likewise, apparent differences in population age structure and mean length at age between the two eras are perhaps not as substantial as they appear.

Rising water levels and declining water clarity and quality have precipitated a decline in submersed aquatic vegetation and this has most likely had a negative impact on largemouth bass as well. This habitat type serves as a nursery area for young bass as well as habitat for bluegill,

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the preferred prey of largemouth bass in Crystal Lake. Aquatic macrophytes also tie up nutrients that are otherwise available to fuel the algal blooms that reduce water clarity.

In addition to the loss of vital aquatic macrophytes, another contributing factor to reduced recruitment of largemouth bass may be linked to an alteration of the food web in Crystal Lake. Yellow bass appear to have been introduced to Crystal Lake between 1999 and 2002, at the beginning of the decline in largemouth bass population density. Increasingly turbid conditions favorable to planktivorous fishes, along with large sections of riprapped shoreline utilized by yellow bass for spawning, created a very favorable environment for these fish. By 2015, yellow bass were prolific, with a spring electrofishing catch rate of 162 fish/mile (317 fish/hr.). Peaks in the length frequency distribution combined with yellow bass length at age data from other studies indicated age 1 through age 4 yellow bass were likely present in 2015. Yellow bass are a generalist feeder, utilizing zooplankton, micro crustaceans, aquatic insect larvae, fish (including small yellow bass), and fish eggs as food (Bulkley 1970, Bulkley 1976, Driscoll and Miranda 1999). In Clear Lake, Iowa, young-of-year yellow bass were shown to rely heavily on copepods and smaller *Daphnia* during their first growing season (Bulkley 1970). Zooplankton, and particularly large *Daphnia* were a major food item for yellow bass in the winter and spring (Bulkley 1970).

One possibility is that diet overlap between introduced yellow bass and age 0 largemouth bass may be leading to increased competition for zooplankton, reducing growth rates of age 0 largemouth bass, and ultimately impacting recruitment to age 1+. Yellow bass diets may also overlap significantly with various life stages of other panfish species which may explain, at least in part, declines in growth of those fish in Crystal Lake. However, one might expect that if competition for zooplankton was enough to negatively impact recruitment of bass that impacts to planktivorous species with early life history requirements similar to bass would not be limited to reduced growth and would include reduced recruitment as well. This has not been the case; bluegill, crappie, and yellow perch abundances appear to have increased over time.

Driscoll and Miranda (1999) noted that yellow bass consumed large quantities of fish eggs in an oxbow of the Mississippi River, although which species' eggs were consumed was not clear. Although the potential exists for yellow bass to impact largemouth bass recruitment via egg predation and reduced nesting success, concrete evidence of this phenomenon in Crystal Lake is lacking. Despite these possibilities, too little is known about specific interactions between yellow

bass and other fish species in Crystal Lake to precisely determine the impact yellow bass have had on the fishery. Yellow bass typically exist as part of a diverse and predator-rich fish community in large rivers and their impoundments. Cases like Crystal Lake where yellow bass have been introduced into smaller, closed lake systems with simple fish assemblages and few predators are lacking for comparison. It should simply be recognized that they have become prolific in Crystal Lake and have contributed to changes in the lake in some way.

Other factors that may have negatively impacted the largemouth bass population since 1999 are disease (largemouth bass virus, evidence lacking) and overpopulation. Unmuth and Larson (2000) noted that the exceptionally high bass densities in Crystal Lake may have exceeded the carrying capacity, there were more bass than the amount of available prey could support, and there was concern for a population crash. Three bass autopsied in October 2000 were found to have zero mesenteric fat and one fish had an off-color gallbladder, indicating it had not consumed food in at least one week (Unmuth and Larson 2000). At any rate, the decline of the largemouth bass population in Crystal Lake is likely due to a combination of several factors rather than one single root cause.

The management goal for largemouth bass in Crystal Lake is to maintain a balanced population that offers anglers a good opportunity to catch harvestable fish while maintaining bass predation pressure on small panfish. The objectives are a spring electrofishing (SE2) CPE8 of 20 to 30 fish/mile, with a PSD between 40 and 70, and an PSD-P value between 10 and 40. These are presented as generally accepted PSD ranges for balanced fish populations in Willis et al. (1993). Based on the 2014 survey, the CPE8 objective is being met at 28.2 fish/mile, and the size structure objectives are currently being met. Future surveys should continue to monitor these metrics for upward or downward fluctuations, and to determine whether objectives are being met. Specifically, it is recommended that at minimum an electrofishing survey should be conducted in spring of 2020 (SE2), representing the half-way point between comprehensive surveys. This survey will assess whether catch rates, specifically catch rates of smaller bass, remain at low levels.

Because population goals and objectives are currently being met, changes to largemouth bass regulations on Crystal Lake are not currently recommended. However, the precipitous decline observed in the largemouth bass population since 1999 is cause for concern. It appears that the decline is driven largely by a lack of recruitment due to habitat degradation and loss, along with a

potential food web interaction with yellow bass. Further quantifying largemouth bass recruitment is of value, particularly if a population response due to habitat improvement is to be evaluated. Completing an annual SE2 survey is one method of evaluating recruitment. However, juvenile largemouth bass have not historically captured in great numbers during boat electrofishing surveys of Crystal Lake. Sampling near shore areas with a barge electrofishing unit or by seining are alternative methods for assessing largemouth bass recruitment, although similar data from other systems for comparison are likely lacking.

Based on the hypothesis that declines in the largemouth bass population over the past 15-20 years have been caused by a combination of reduced water quality, habitat loss, and changes within the fish community, efforts should be focused on remedying these causative factors with the goal of reversing the decline in bass. Improvements in these areas should lead to a positive response in bass recruitment and an increase in abundance. Stocking largemouth bass is not currently recommended.

However, stocking other predator species as a means of increasing predator densities and thus predation pressure on planktivores should be explored. Channel catfish and walleyes are two species that can be successful in shallow, warm, turbid systems. Currently, there is an annual stocking quota for Crystal Lake for 10 large fingerling channel catfish/acre. The State of Wisconsin does not raise channel catfish in its hatcheries, so catfish will only be stocked when surplus is available from Genoa National Fish Hatchery, or when funding allows the purchase of fish from a private vendor such as occurred in 2017 (Table 2). Walleye stocking could also be explored as a means of increasing predator density in the lake but more study and public input are required. Successful walleye stocking may lead to the expectation that the stocking continues even if conditions improve and the largemouth bass population recovers.

Yellow perch are common in Crystal Lake and provide a harvest opportunity to anglers that complements other panfish opportunities. Comparable data from the last 20 years are limited to an early spring fyke net survey in late March and early April of 1999. During that survey, 138 yellow perch were collected and the fyke net CPE was 3.1 fish/net night. The PSD, PSD-9, and PSD-P values in 1999 were 93, 20, and zero, respectively. The yellow perch catch rate was higher in 2015 (11.6 fish/net night) which may indicate increased abundance, but may also be an artifact of net locations and water temperatures during the time of sampling. Size structure has been greatly reduced from 1999 values, with PSD, PSD-9, and PSD-P values of 23, 3, and zero,

respectively in 2015. Also, as previously noted, yellow perch growth has declined markedly after age 2, with the mean length at age 4 declining by 2.5 inches from 1999 to 2015 (Figure 18). The decline in perch growth over time fits with the observed increase in abundance.

The overall estimate of total annual mortality in Crystal Lake (69% for ages 4 to 8+, sexes combined) is consistent with rates observed in other exploited Wisconsin populations (Goedde and Coble 1981). However, separate estimates for females (88% for ages 5 to 7+) and males (46% for ages 4 to 7) indicate that harvest likely impacts female yellow perch to a much higher degree than males in Crystal Lake, with the annual mortality rate of females nearly double that of males. This is most likely due to the larger body size of females compared to males making them more desirable to anglers. There are no species-specific goals or objectives for yellow perch in Crystal Lake. No regulation change is currently recommended.

Finally, in recent years the Fish, Crystal, and Mud Lake Rehabilitation District has been permitted to operate a pumping system to remove water from Crystal Lake. The goal of the pumping has been to lower the water level in Crystal Lake to avoid threats to riparian properties, roads, and other infrastructure, and to make the lake more accessible for fishing and other recreational uses. As the pumping continues, lower and more stable water levels may allow for some recovery of the aquatic macrophyte community in Crystal Lake. Periodic point-intercept plant surveys offer a means of assessing recovery or further reductions in the aquatic plant community. However, regularly performing sonar-based surveys (e.g. CI BioBase) would offer a more rapid and rough-scale method of assessing changes in the aquatic plant community by identifying areas of changing aquatic plant biomass without identifying changes in overall species richness or abundance of individual species. Sonar-based surveys are easier and less costly to perform than full point-intercept surveys and could be conducted annually to track changes in the plant community.

One potential action that could improve water clarity and allow for recovery of aquatic macrophytes is chemical carp removal. Because of the relatively large volume of water in Crystal Lake and the lack of a mechanism for a drastic lowering of the water level, chemical removal of carp with rotenone is not likely to be feasible. In addition to generating data on the aquatic plant community, sonar-based surveys also yield calculations of lake volume which is a necessary component in estimating the cost of carp eradication using rotenone. It is recommended that this

type of survey be conducted during the summer as soon as possible to generate a map of aquatic plant density as well as an estimate of lake volume.

If chemical carp removal is not feasible, it is recommended that commercial harvest be explored instead as a removal strategy. In either case, the goal would be to lower carp biomass to a manageable level to improve water clarity and increase aquatic macrophyte abundance. The objective is a common carp biomass <100 pounds/acre. A spring electrofishing survey where only common carp are collected, measured, and weighed is recommended to more accurately assess carp abundance, biomass, and population size structure in Crystal Lake. These data will inform future carp management strategies.

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TABLES AND FIGURES

Table 1. Current fishing regulations and open season dates for Crystal Lake, Dane County, Wisconsin.

Species	Season Dates	Length and Bag Limits
Catfish	Open All Year	No minimum length limit and the daily bag limit is 10.
Bullheads	Open All Year	No minimum length limit and no daily bag limit.
Panfish (bluegill, pumpkinseed, sunfish, crappie, and yellow perch)	Open All Year	No minimum length limit and the daily bag limit is 25.
Largemouth bass and smallmouth bass	First Saturday in May through the first Sunday in March	The minimum length limit is 14" and the daily bag limit is 5.
Northern pike	First Saturday in May through the first Sunday in March	The minimum length limit is 26" and the daily bag limit is 2.
Walleye, sauger, and hybrids	First Saturday in May through the first Sunday in March	The minimum length limit is 15" and the daily bag limit is 5.
Rough fish	Open All Year	No minimum length limit and no daily bag limit.
Rock, yellow, and white bass	Open All Year	No minimum length limit and no daily bag limit.

Table 2. Stocking history for Crystal Lake, Dane County, Wisconsin, 1972-2017.

Year	Species	Strain (Stock)	Age Class	Number Stocked	Avg. Fish Length (inches)	Source
1973	WALLEYE	UNSPECIFIED	ADULT	500	13.0	FEDERAL HATCHERY
1988	LARGEMOUTH BASS	UNSPECIFIED	FINGERLING	2,500	3.0	DNR HATCHERY
1987	LARGEMOUTH BASS	UNSPECIFIED	FINGERLING	30,000	1.0	DNR COOP PONDS
1989	LARGEMOUTH BASS	UNSPECIFIED	FINGERLING	2,500	1.0	DNR COOP PONDS
2003	YELLOW PERCH	UNSPECIFIED	LARGE FINGERLING	11,800	4.5	PRIVATE HATCHERY
2004	YELLOW PERCH	UNSPECIFIED	LARGE FINGERLING	9,800	5.0	PRIVATE HATCHERY
2017	CHANNEL CATFISH	UNSPECIFIED	YEARLING	2,000	6.1	PRIVATE HATCHERY

Table 3. Locations of fyke nets (GPS coordinates) used during spring fyke netting on Crystal Lake, Dane County, Wisconsin in 2015.

Net Number	Date First Set	Date Last Lifted	Latitude	Longitude
1	03/24/2015	04/03/2015	43.28533	-89.60709
2	03/24/2015	04/03/2015	43.29353	-89.61213
3	03/24/2015	03/30/2015	43.29358	-89.62096
4	03/24/2015	04/03/2015	43.29807	-89.63654
5	03/24/2015	04/03/2015	43.29580	-89.63869
6	03/24/2015	03/28/2015	43.29153	-89.63740
7	03/30/2015	03/31/2015	43.29530	-89.63404

Table 4. Hard structures used to estimate age for the various fish species collected during the 2015 survey of Crystal Lake, Dane County, Wisconsin.

Species	Size Category	Structure
Black crappie	ALL	scale
White crappie	ALL	scale
Bluegill	ALL	scale
Largemouth bass	≤8 inches	scale
Largemouth bass	≥8 inches	dorsal spine
Northern pike	ALL	anal fin ray
Yellow perch	ALL	anal fin spine

Table 5. Locations of electrofishing stations (GPS coordinates) sampled during spring electrofishing on Crystal Lake, Dane County, Wisconsin in 2015.

Date	Station[1]	Distance	Start Latitude	Start Longitude	End Latitude	End Longitude
05/13/2015	PANFISH 1	0.5	43.29112	-89.63232	43.29536	-89.63093
05/13/2015	GAMEFISH 1	1.5	43.29536	-89.63093	43.28986	-89.63767
05/13/2015	PANFISH 2	0.5	43.28986	-89.63767	43.28645	-89.63104
05/13/2015	GAMEFISH 2	1.5	43.28645	-89.63104	43.29112	-89.63237
05/28/2015	PANFISH 3	0.5	43.29142	-89.61559	43.29426	-89.62206
05/28/2015	BASS PE	6.0	ENTIRE	SHORE		

[1]Panfish 3 was contained within the Bass PE station, but fish data was recorded separately.

Table 6. Proportional size distribution (PSD) length categories (inches) used for sport fish species collected from Crystal Lake, Dane County, Wisconsin in 2015 (based on Anderson and Neumann 1996).

Species	Stock	Quality (PSD)	Harvest (PSD-H)[1]	Preferred (PSD-P)	Memorable (PSD-M)	Trophy (PSD-T)
Bluegill	3	6	7 (Angler)	8	10	12
Black crappie	5	8	9 (Angler)	10	12	15
White crappie	5	8	9 (Angler)	10	12	15
Yellow perch	5	8	9 (Angler)	10	12	15
Largemouth bass	8	12	14 (Legal)	15	20	25
Northern pike	14	21	26 (Legal)	28	34	44

[1]The harvest column refers to size at which anglers are likely to harvest panfish, or the legal minimum length at which gamefish may be harvested in Wisconsin.

Table 7. Summary of catch and catch per unit effort (CPE) by gear type for spring netting period 1 (SN1) and spring electrofishing period 2 (SE2) on Crystal Lake, Dane County, Wisconsin in 2015.

| | CATCH | | | CPE Fish/net night | Fish/hour | Fish/mile | Percent of |
Species	SN1	SE2	TOTAL	SN1[1]	SE2[2]	SE2[3]	Catch
Bluegill	3,234	119	3,353	63.4	154.5	79.3	52.0%
Black crappie	769	7	776	15.1	9.1	4.7	12.0%
Yellow perch	590	11	601	11.6	14.3	7.3	9.3%
Largemouth bass	57	298	355	1.1	49.7	28.2	5.5%
Yellow bullhead	319	5	324	6.3	6.5	3.3	5.0%
Pumpkinseed	244	14	258	4.8	18.2	9.3	4.0%
Yellow bass	0	244	244	0.0	316.9	162.7	3.8%
Golden shiner	202	4	206	4.0	5.2	2.7	3.2%
Brown bullhead	133	33	166	2.6	42.9	22.0	2.6%
Common carp	17	59	76	0.3	76.6	39.3	1.2%
White crappie	67	1	68	1.3	1.3	0.7	1.1%
Northern pike	25	0	25	0.5	0.0	0.0	0.4%
Green sunfish	5	1	6	0.1	1.3	0.7	0.1%
White bass	0	2	2	0.0	2.6	1.3	0.0%
Sauger	1	0	1	0.0	0.0	0.0	0.0%
Totals	5,663	798	6,452				

[1]Total fyke netting effort during SN1 was 51 net nights.
[2]During SE2, total "on" time was 6.0 hours for gamefish, and was 0.77 hours for panfish.
[3]During SE2, total shoreline distance was 12.6 miles for gamefish and 1.5 miles for panfish.

Table 8. Summary of lengths (inches), proportional size distribution (PSD) values, and age of male (M), female (F) or all panfish and gamefish collected during the 2015 spring netting period 1 (SN1) and spring electrofishing period 2 (SE2) surveys of Crystal Lake, Dane County, Wisconsin.

Species	Period	N Collected	N Measured	Min. Length	Max. Length	Mean Length	Median Length	Mode	PSD	PSD-H	PSD-P	Min Age	Max Age
Bluegill	SN1	3,234	2,638	3.0	8.4	6.3	6.5	7.0	71	30	1	2	8
Bluegill	SE2	119	119	3.4	7.6	6.4	6.7	7.0	78	36	0		
Black crappie	SN1	769	756	3.6	10.6	8.3	8.4	8.4	77	17	1	1	7
Black crappie	SE2	7	7	8.4	9.5	8.9	8.8						
White crappie	SN1	67	67	3.7	11.6	8.5	8.3	7.8				1	5
Yellow perch	SN1-M	491	491	5.3	8.9	7.2	7.4	7.3	11	0	0	2	7
Yellow perch	SN1-F	99	99	5.8	9.8	8.3	8.4	8.2				3	9
Yellow perch	SN1-All	590	590	5.3	9.8	7.4	7.5	7.3	23	3	0	2	9
Yellow perch	SE2	11	11	3.1	6.8	4.5	4.0	4.0					
Largemouth bass	SN1	57	56	5.5	22.1	12.8	11.8	10.1					
Largemouth bass	SE2	298	285	4.4	20.8	12.7	11.8	11.1	49	33	26	1	22
Northern pike	SN1	26	18	19.6	34.3	26.0	24.5	24.0				4	11

Table 9. Total annual survival (S), total annual mortality (M), and instantaneous mortality (Z) estimates for panfish and gamefish species collected during the 2015 survey of Crystal Lake, Dane County, Wisconsin.

Species	Sex	Age Fully Vulnerable to Sample Gear	Z	S	M
Bluegill	ALL	3	-0.9549	38%	62%
Black crappie	ALL	4	-1.7165	18%	82%
Yellow perch	FEMALE	5	-2.0896	12%	88%
Yellow perch	MALE	4	-0.6221	54%	46%
Yellow perch	ALL	4	-1.1869	31%	69%
Largemouth bass	ALL	4	-0.2136	81%	19%

Table 10. Mean age at 14.0-14.9 inches (MAL14) for largemouth bass (LMB) populations in 12 Columbia, Sauk, and Dane County lakes (13 surveys), 2006-2015.

Waterbody	County	Year	MAL14	LMB Density	Prey Base[1]
Lake Wisconsin	Columbia	2012	4.8	Low	GZS, BLG
Lake Delton	Sauk	2014	4.9	Moderate	BLG
Park Lake	Columbia	2011	5.3	Low	GZS, BLG
Swan Lake	Columbia	2009	5.8	Moderate	GZS, BLG
Redstone Lake	Sauk	2010	6.0	Low	GZS, BLG
Seeley Lake	Sauk	2008	6.1	Moderate	BLG
Mirror Lake	Sauk	2014	6.4	Moderate	BLG
White Mound Lake	Sauk	2013	6.5	High	BLG
Dutch Hollow Lake	Sauk	2006	6.9	High	BLG
White Mound Lake	Sauk	2006	7.2	High	BLG
Crystal Lake	**Dane**	**2015**	**7.5**	**Low**	**BLG**
Fish Lake	Dane	2015	8.1	Moderate	BLG
Devils Lake	Sauk	2013	9.3	High	BLG
Mean-All Lakes			6.5		
Median-All Lakes			6.4		

[1] GZS = gizzard shad; BLG = bluegill.

Table 11. Date of capture, sex, length (inches), weight (pounds), and age of northern pike collected during the 2015 survey of Crystal Lake, Dane County, Wisconsin.

Date of Capture	Sex[1]	Length	Weight	Age
04/03/2015	F	29.9	9.8	8
03/26/2015	F	31.4	9.9	6
04/02/2015	F	32.7		6
03/25/2015	F	33.0	10.7	6
04/03/2015	F	34.3	6.8	6
03/25/2015	M	19.6	1.9	4
03/28/2015	M	20.9	1.9	4
03/25/2015	M	22.5	2.4	4
03/26/2015	M	22.8	2.6	5
03/25/2015	M	23.5	2.6	6
03/25/2015	M	23.7	2.8	5
03/25/2015	M	24.0	3.7	5
03/26/2015	M	24.0	3.0	8
03/25/2015	M	24.2	3.4	6
03/25/2015	M	24.7	3.5	6
03/28/2015	M	25.1	3.8	5
03/25/2015	M	25.4	3.3	11
03/25/2015	M	26.0	3.9	7
	Female Average	32.3	9.3	
	Male Average	23.6	3.0	
	All Average	26.0	4.5	

[1]F refers to female northern pike, M refers to male northern pike.
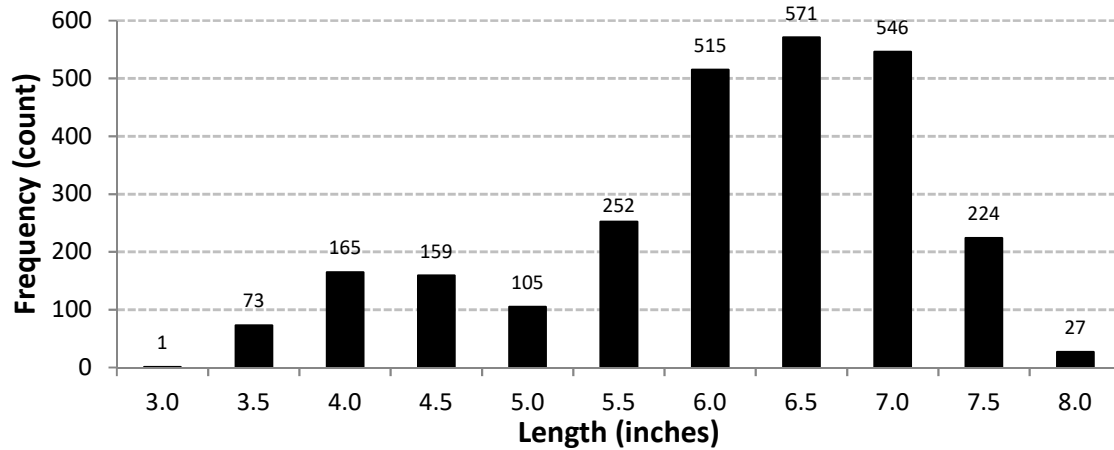
Figure 1. Length frequency distribution of bluegills captured using fyke nets during the spring 2015 survey of Crystal Lake, Dane County, Wisconsin.
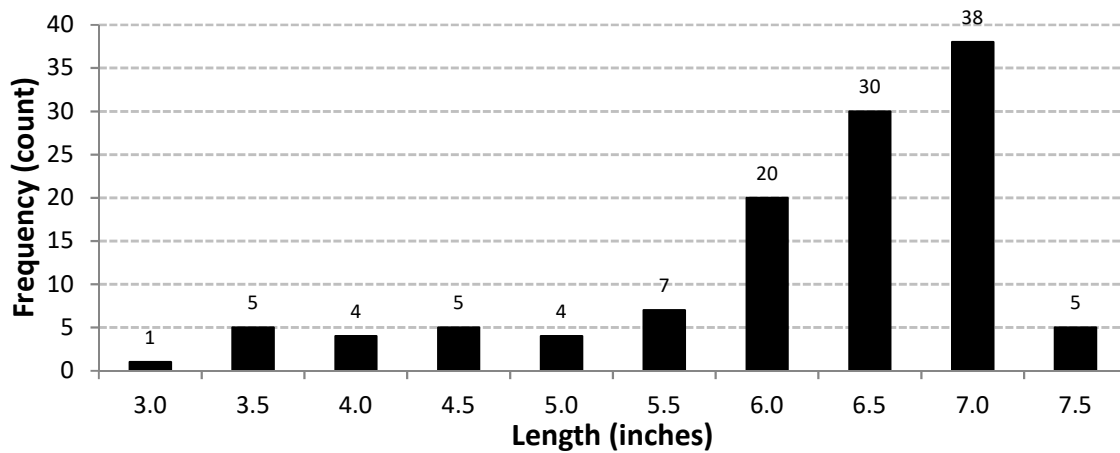
Figure 2. Length frequency distribution of bluegills captured by electrofishing during the spring 2015 survey of Crystal Lake, Dane County, Wisconsin.
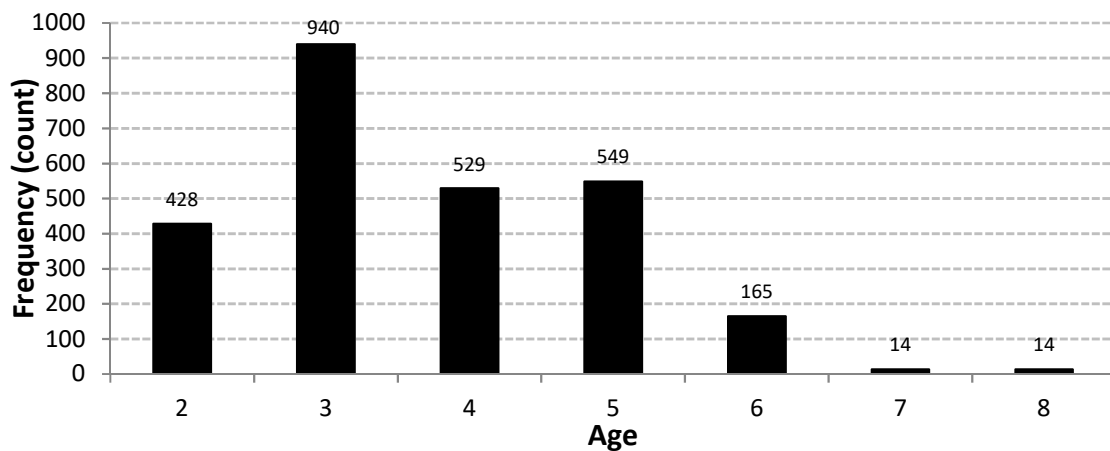
Figure 3. Age frequency distribution of bluegills collected during the spring 2015 survey of Crystal Lake, Dane County, Wisconsin.
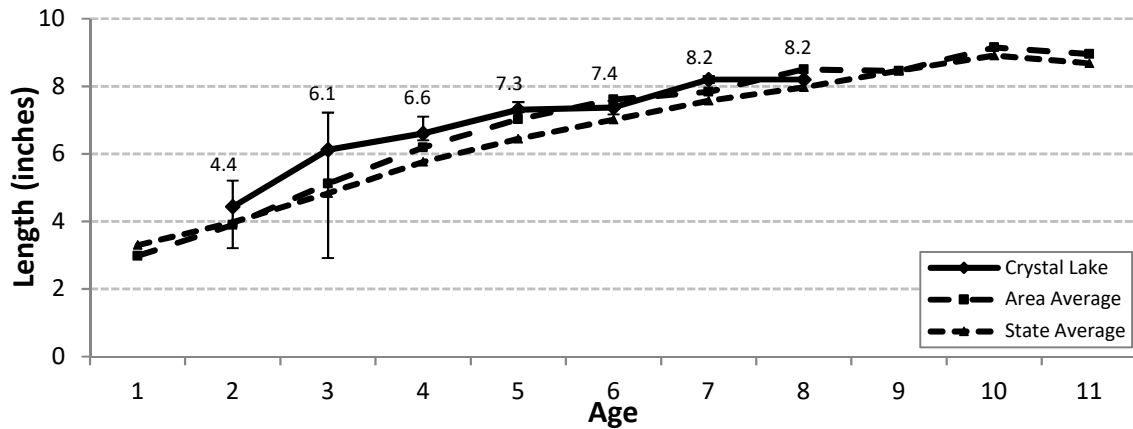
Figure 4. Mean length at age of bluegills captured during the spring 2015 survey of Crystal Lake, Dane County, Wisconsin. Error bars represent minimum and maximum length values for a given age.
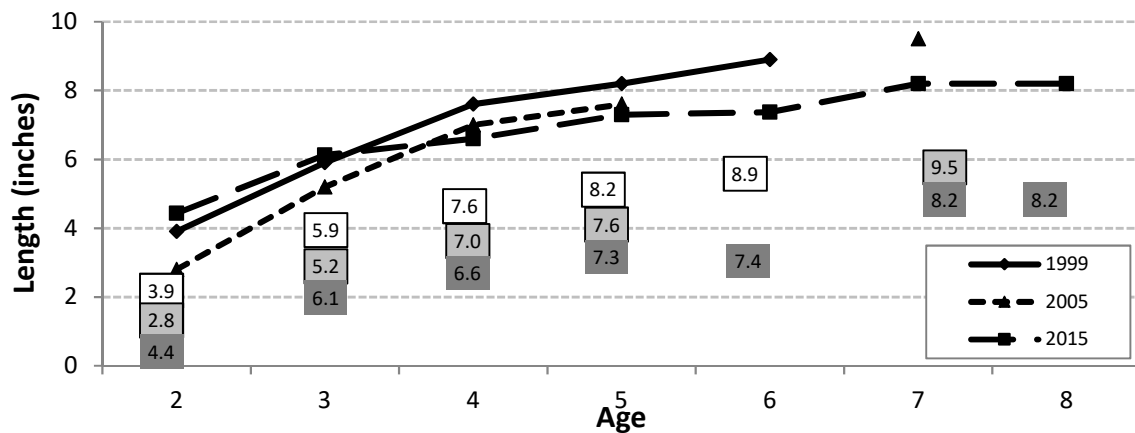
Figure 5. Mean length at age of bluegills captured during surveys of Crystal Lake, Dane County, Wisconsin in 1999, 2005, and 2015. Values from the 1999 survey are represented in the white boxes with black borders. Values from 2005 are represented in the light gray boxes with black borders. Values from 2015 are represented in the dark gray boxes with no borders.
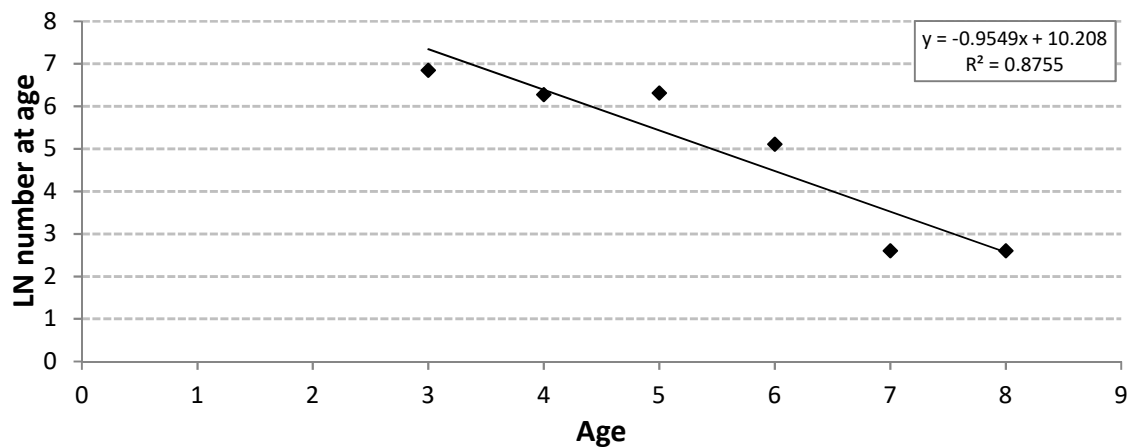
Figure 6. Catch curve for bluegills captured during the 2015 survey of Crystal Lake, Dane County, Wisconsin.
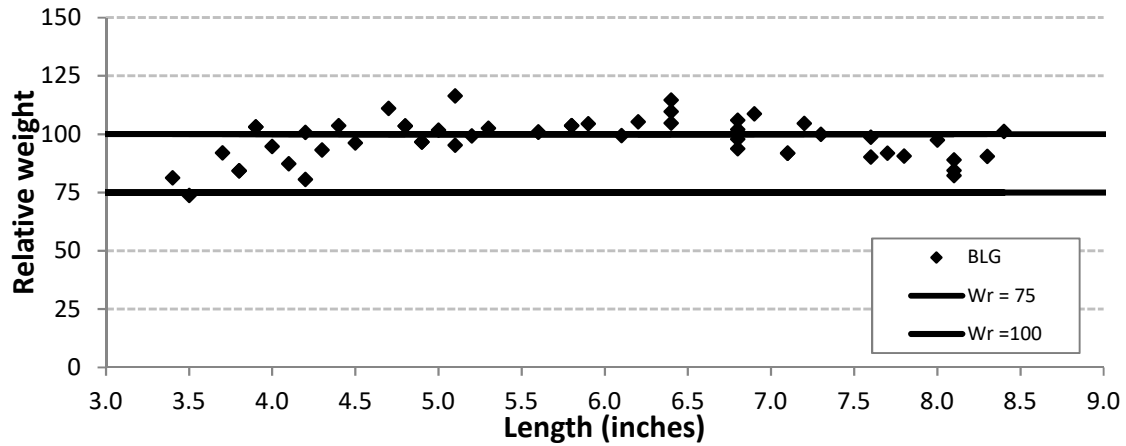
Figure 7. Relative weights of bluegills collected during the 2015 survey of Crystal Lake, Dane County, Wisconsin.
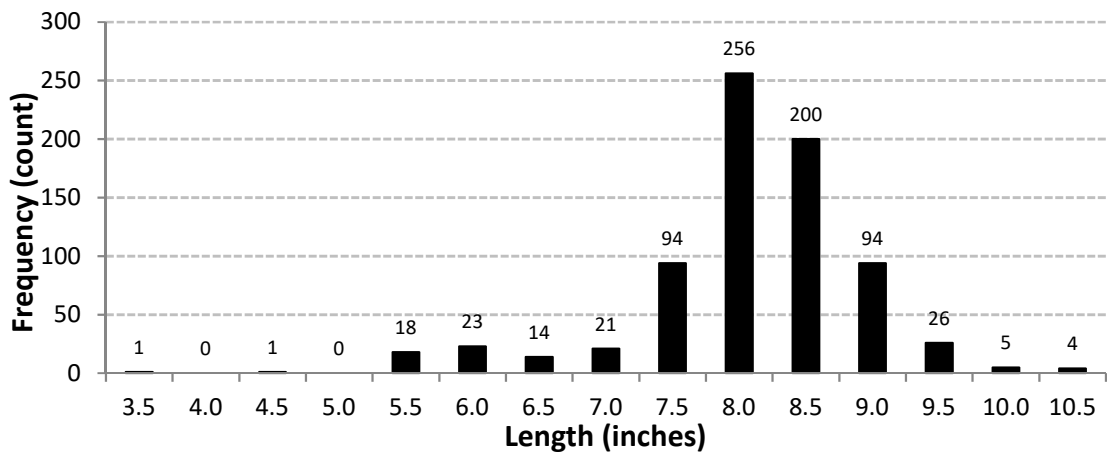
Figure 8. Length frequency distribution of black crappies collected using fyke nets during the 2015 survey of Crystal Lake, Dane County, Wisconsin.
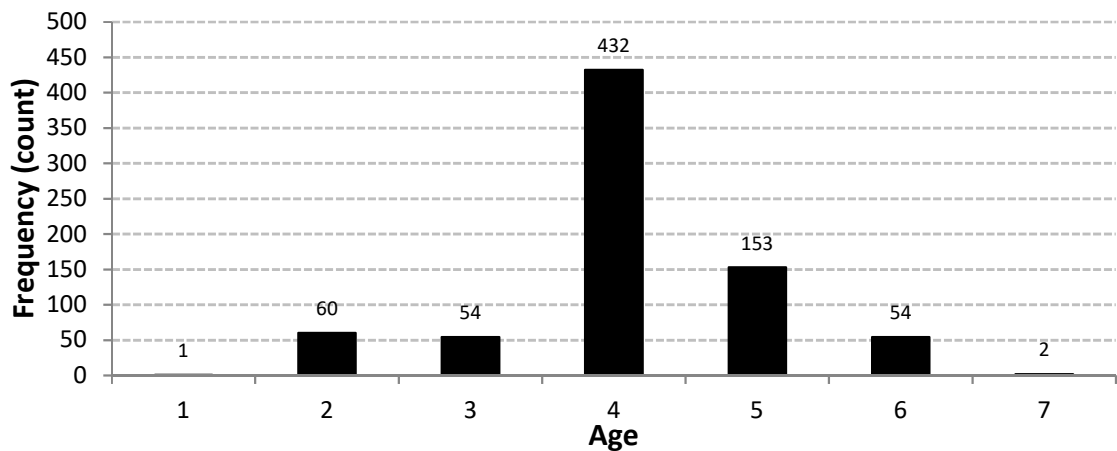

Figure 9. Age frequency distribution of black crappies collected using fyke nets during the 2015 survey of Crystal Lake, Dane County, Wisconsin.
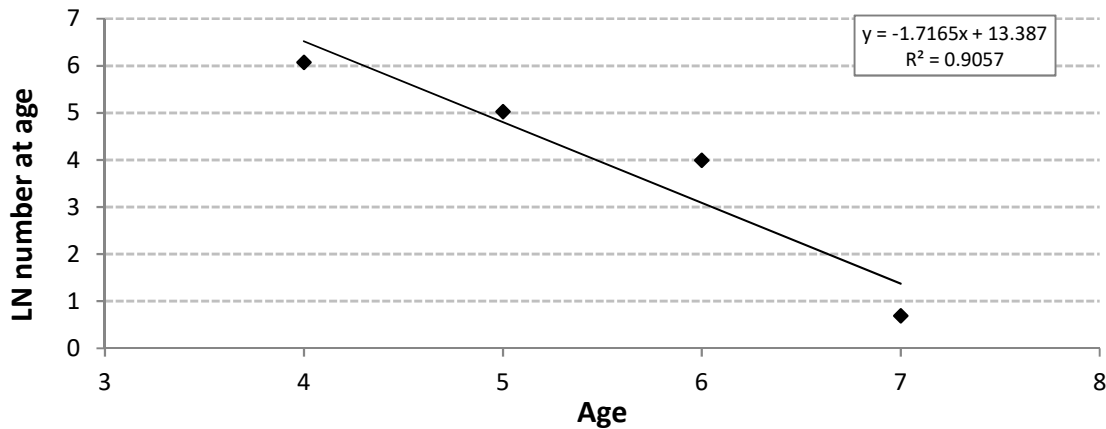
Figure 10. Catch curve for black crappies captured during the 2015 survey of Crystal Lake, Dane County, Wisconsin.
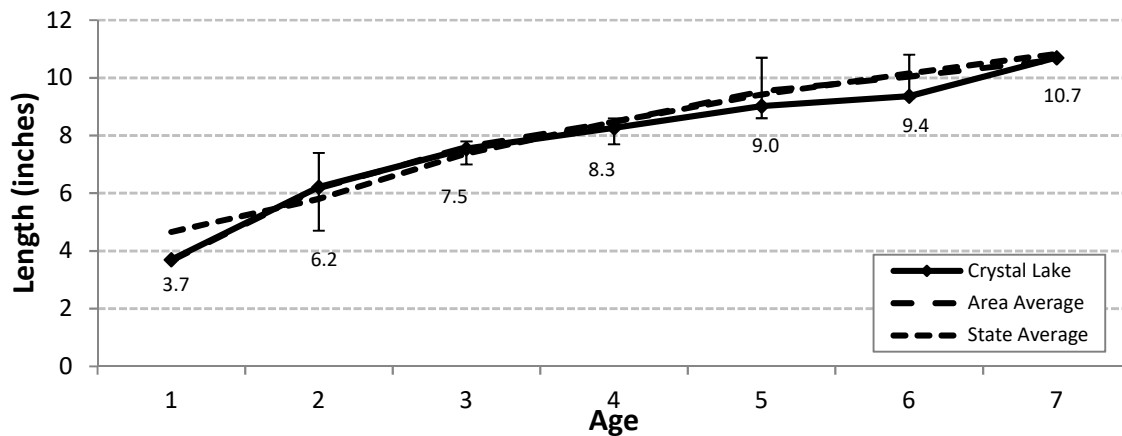
Figure 11. Mean length at age of black crappies captured during the spring 2015 survey of Crystal Lake, Dane County, Wisconsin. Error bars represent minimum and maximum length values for a given age.
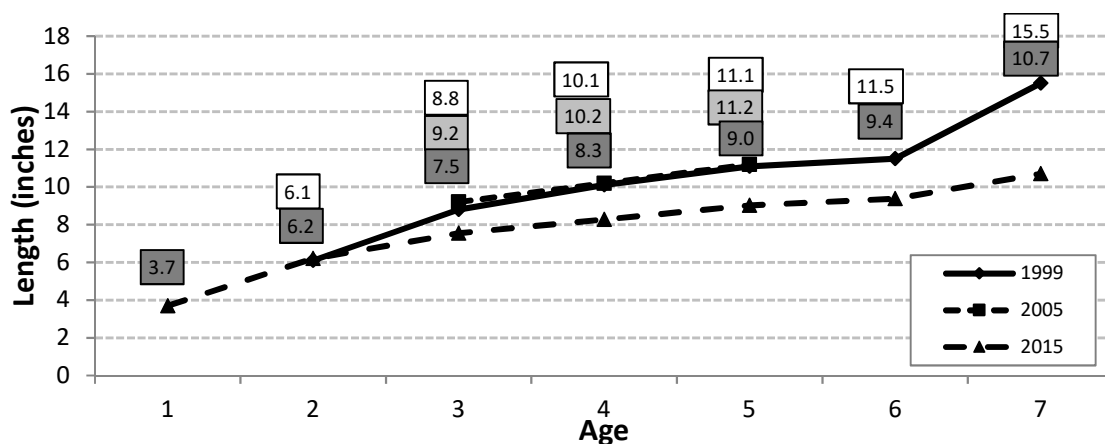

Figure 12. Mean length at age of black crappies captured during surveys of Crystal Lake, Dane County, Wisconsin in 1999, 2005, and 2015. Values from the 1999 survey are represented in the white boxes with black borders. Values from 2005 are represented in the light gray boxes with black borders. Values from 2015 are represented in the dark gray boxes with no borders.
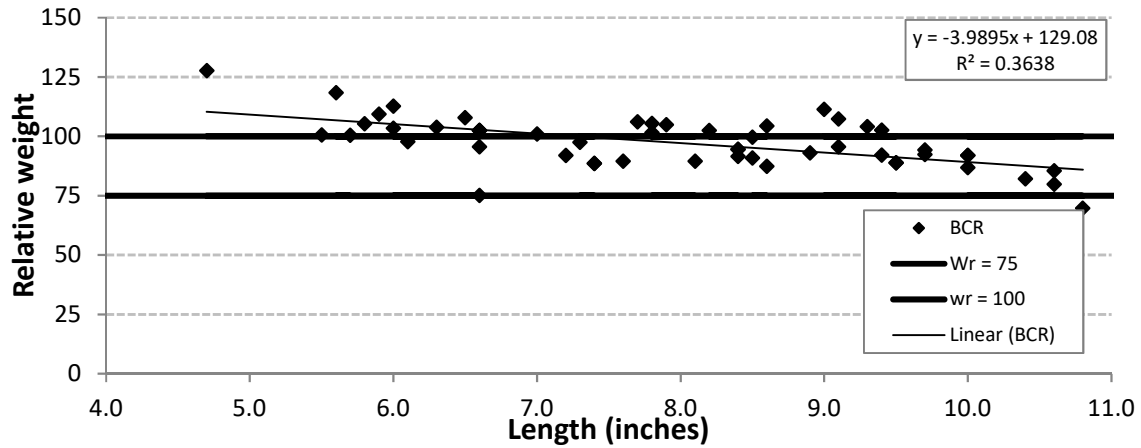
Figure 13. Relative weights of black crappies collected during the 2015 survey of Crystal Lake, Dane County, Wisconsin.
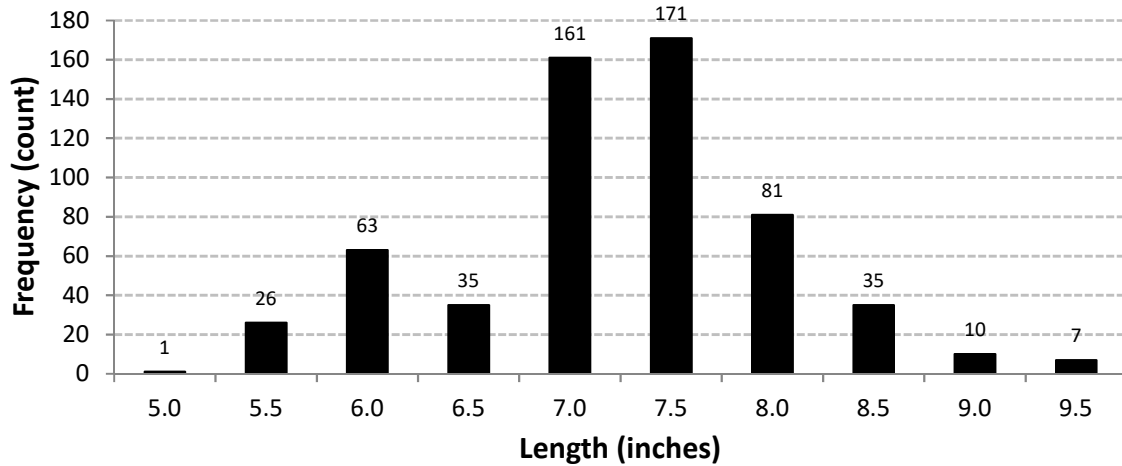
Figure 14. Length frequency distribution of yellow perch collected using fyke nets (sexes combined) during the 2015 survey of Crystal Lake, Dane County, Wisconsin.
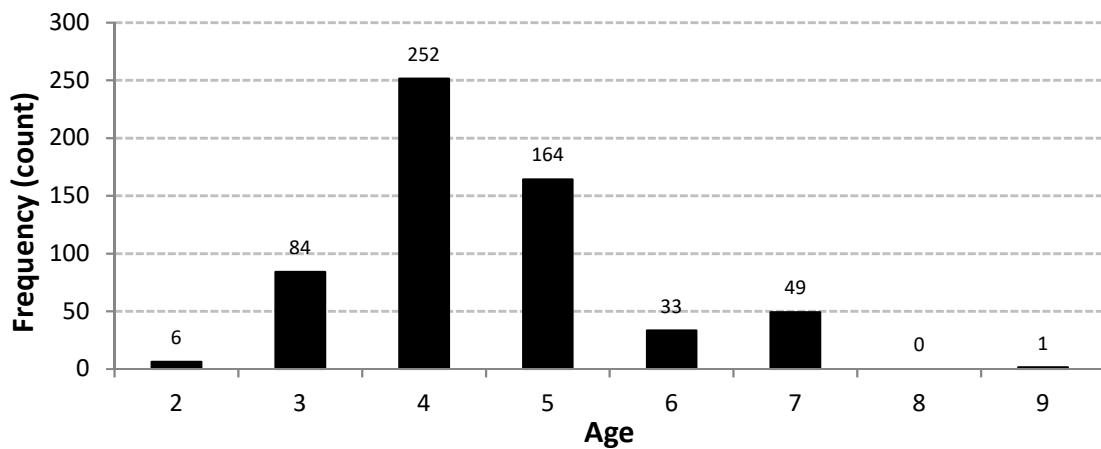
Figure 15. Age frequency distribution of yellow perch collected using fyke nets (sexes combined) during the 2015 survey of Crystal Lake, Dane County, Wisconsin.
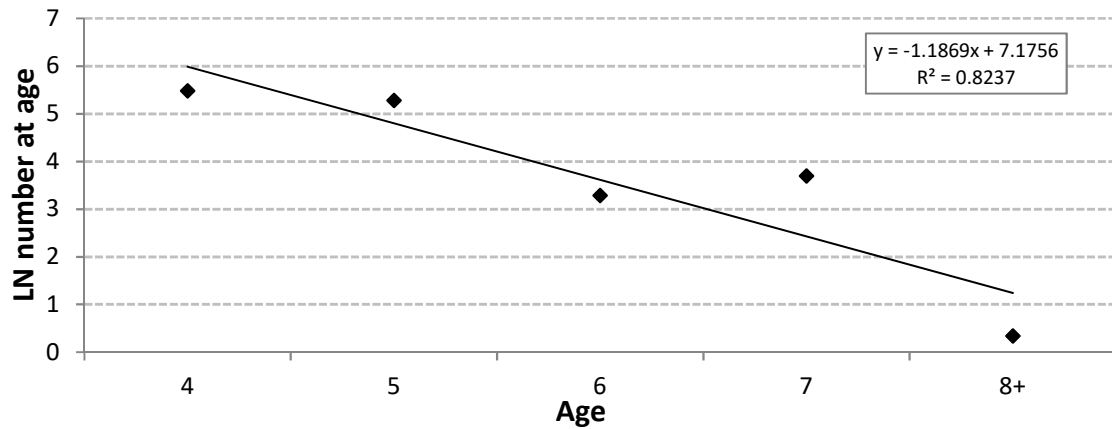
Figure 16. Catch curve for yellow perch (sexes combined) collected during the 2015 survey of Crystal Lake, Dane County, Wisconsin.
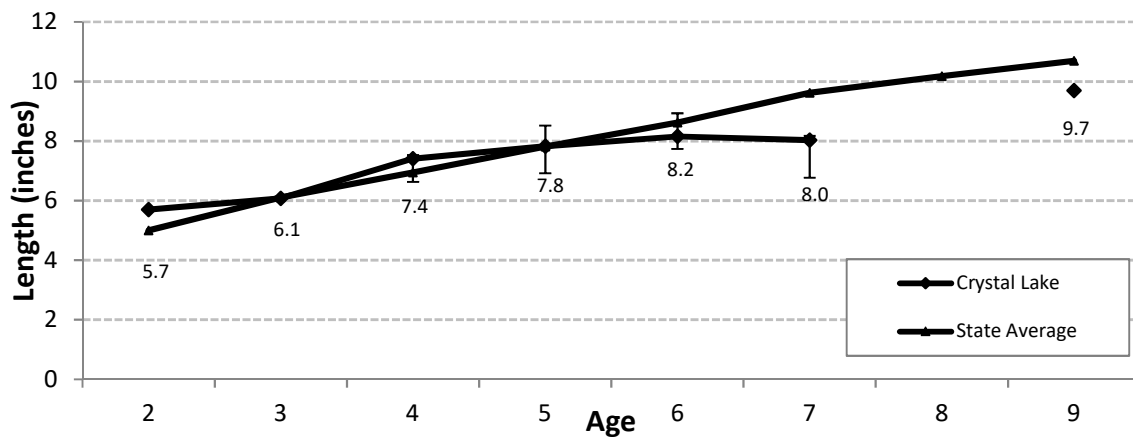
Figure 17. Mean length at age of yellow perch (sexes combined) collected during the 2015 survey of Crystal Lake, Dane County, Wisconsin. Error bars represent minimum and maximum length values for a given age.
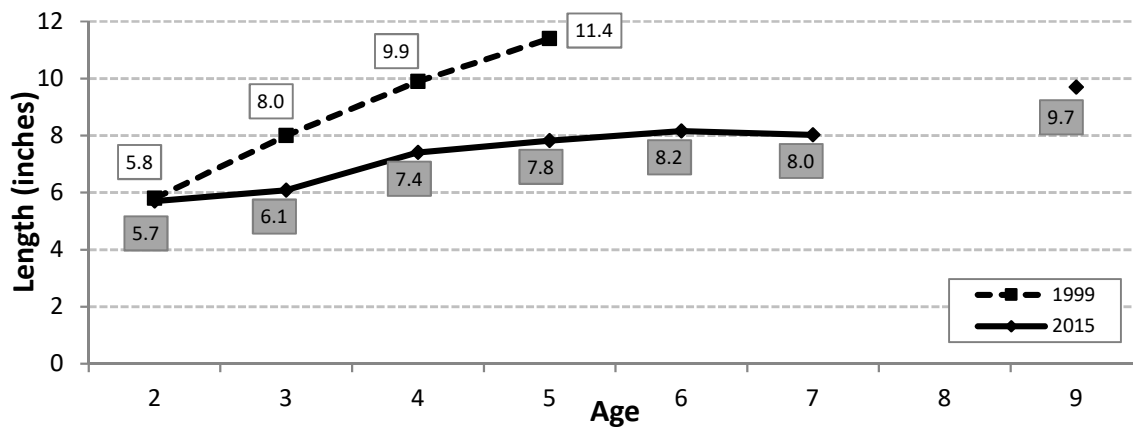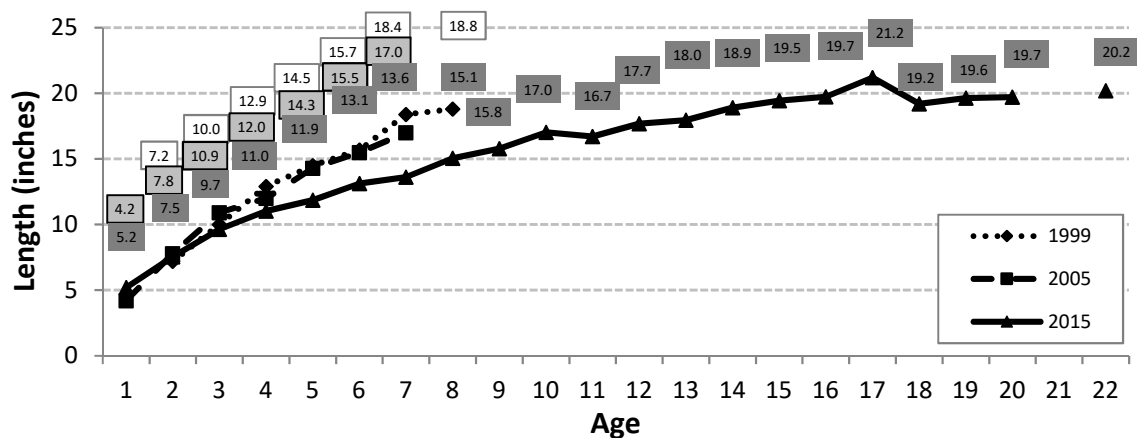

Figure 18. Mean length at age of yellow perch (sexes combined) collected during the 1999 and 2015 surveys of Crystal Lake, Dane County, Wisconsin. Values from the 1999 survey are represented in the white boxes with black borders. Values from the 2015 survey are represented in the light gray boxes with no borders.
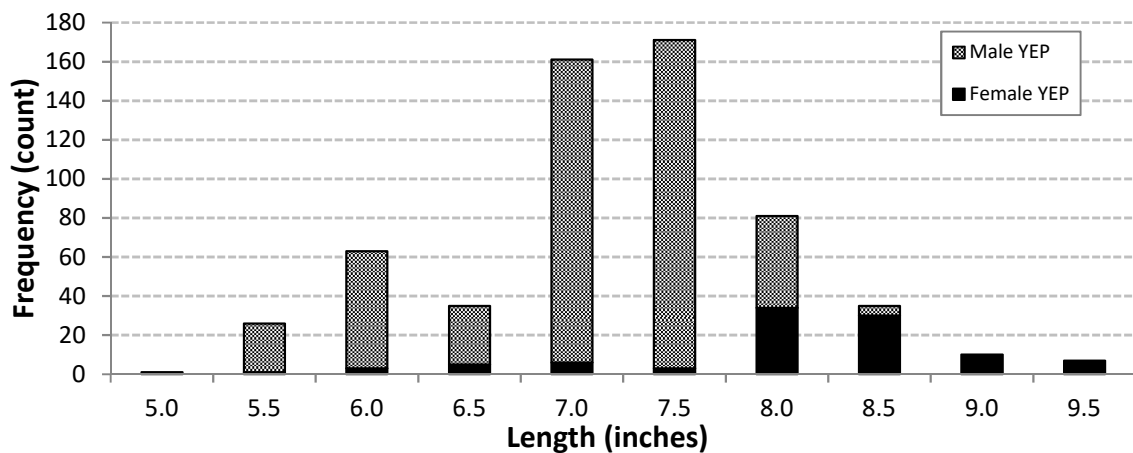
Figure 19. Length frequency distribution of yellow perch collected using fyke nets (separated by sex) during the 2015 survey of Crystal Lake, Dane County, Wisconsin.
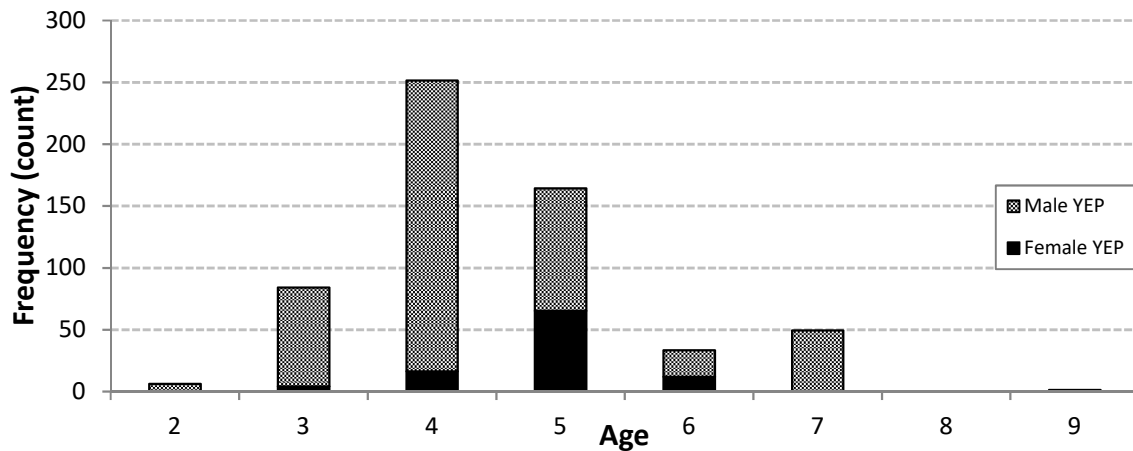
Figure 20. Age frequency distribution of yellow perch collected using fyke nets (separated by sex) during the 2015 survey of Crystal Lake, Dane County, Wisconsin.
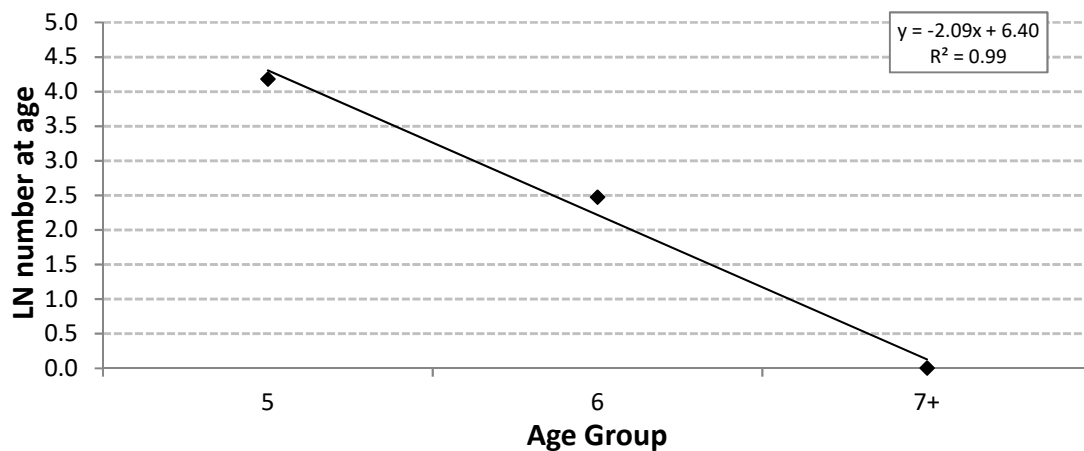
Figure 21. Catch curve for female yellow perch collected during the 2015 survey of Crystal Lake, Dane County, Wisconsin.

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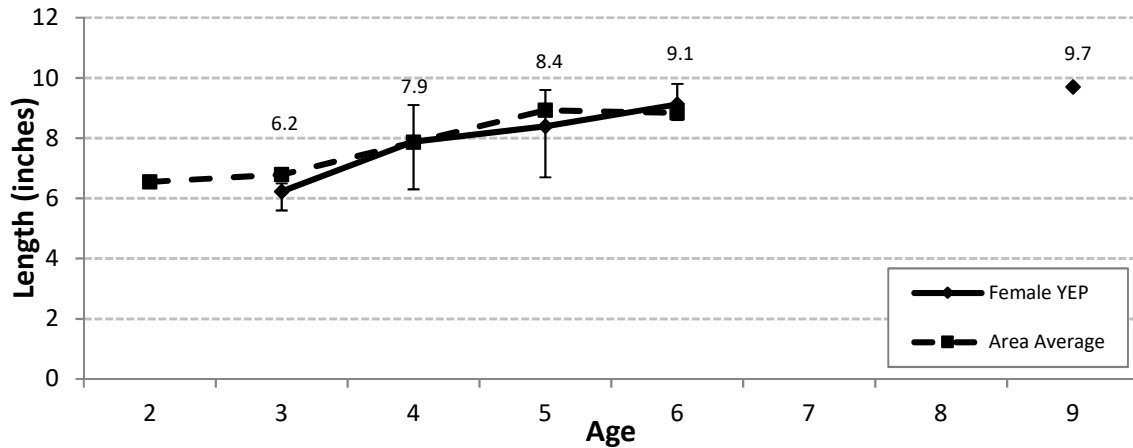
Figure 22. Mean length at age of female yellow perch collected during the 2015 survey of Crystal Lake, Dane County, Wisconsin. Error bars represent minimum and maximum length values for a given age.
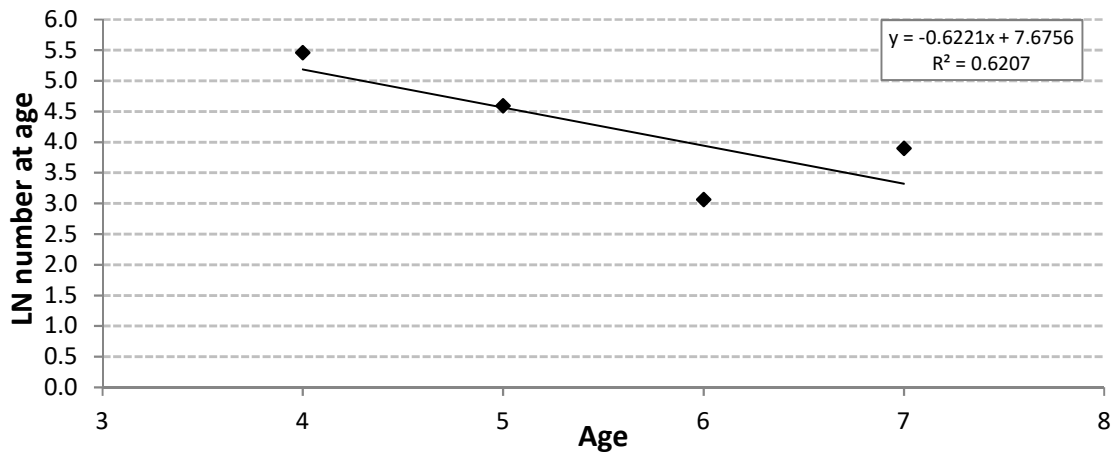
Figure 23. Catch curve for male yellow perch collected during the 2015 survey of Crystal Lake, Dane County, Wisconsin.
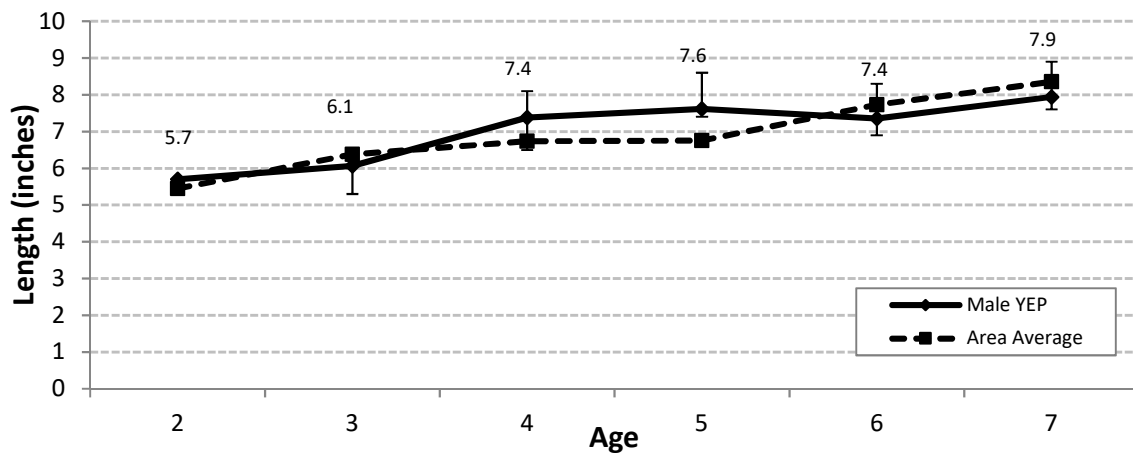
Figure 24. Mean length at age of male yellow perch collected during the 2015 survey of Crystal Lake, Dane County, Wisconsin. Error bars represent minimum and maximum length values for a given age.
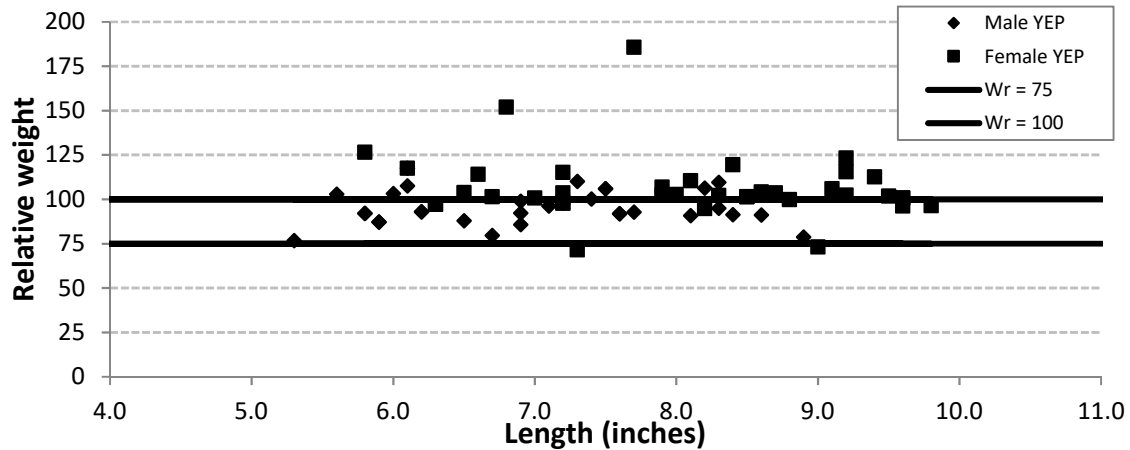
Figure 25. Relative weights of yellow perch collected during the 2015 survey of Crystal Lake, Dane County, Wisconsin.
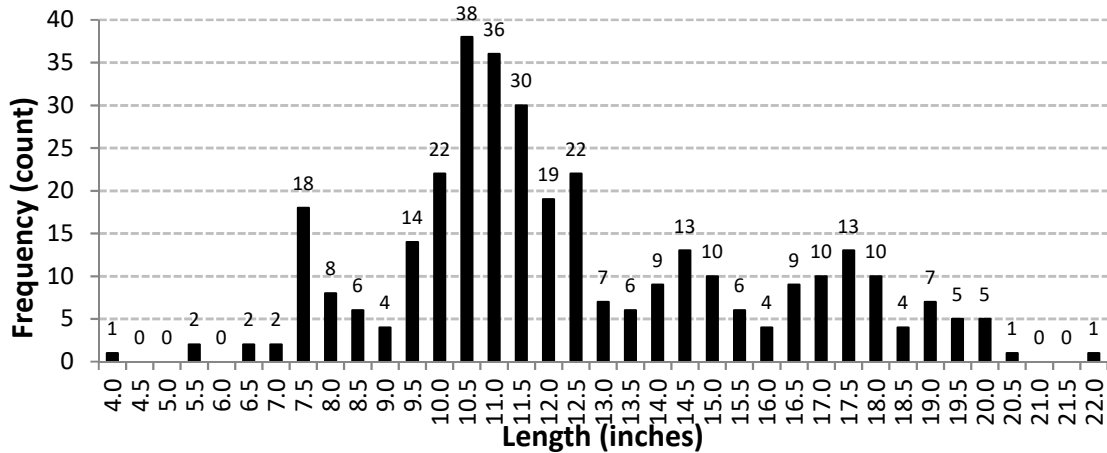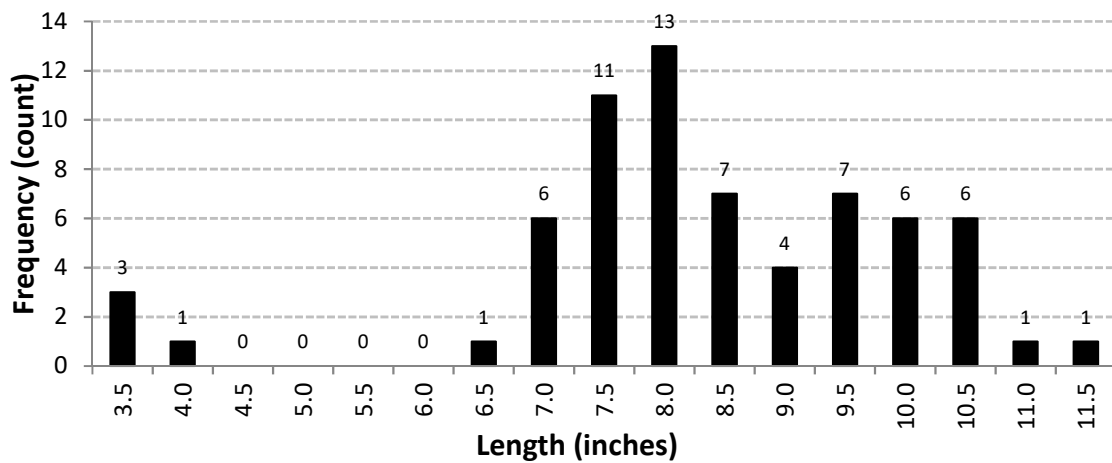

Figure 26. Length frequency distribution of largemouth bass collected during the 2015 survey of Crystal Lake, Dane County, Wisconsin.
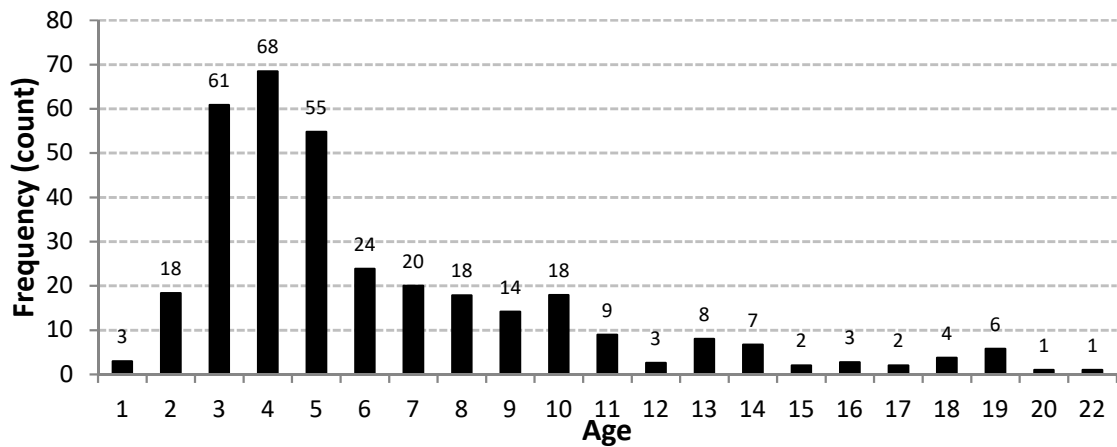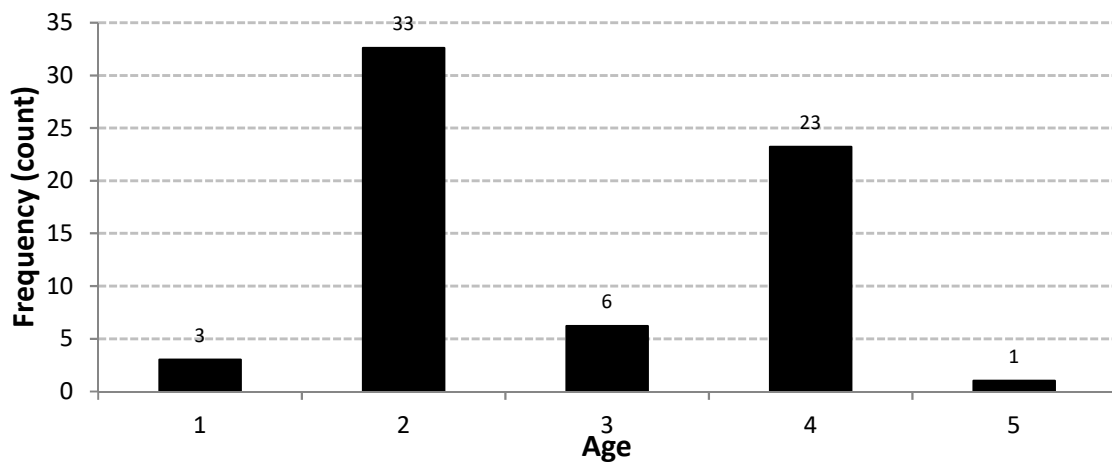

Figure 27. Age frequency distribution of largemouth bass collected during the 2015 survey of Crystal Lake, Dane County, Wisconsin.
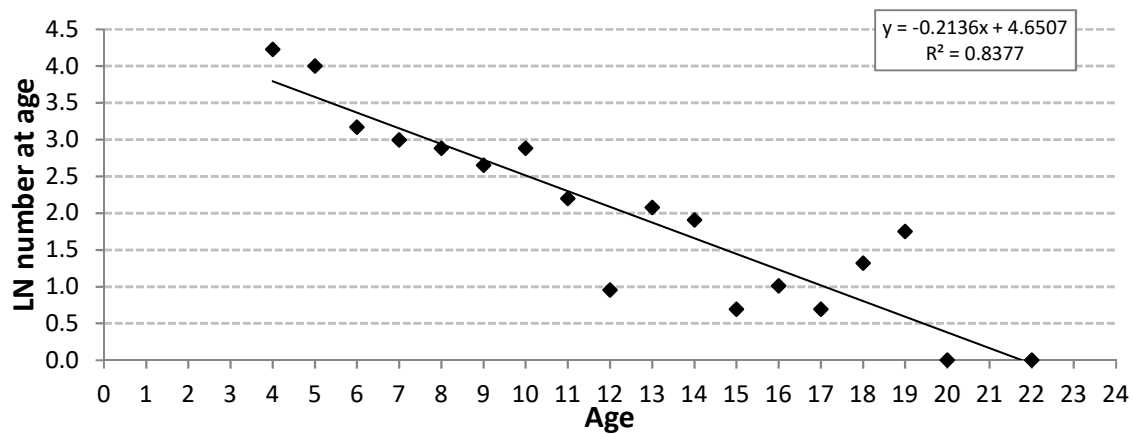
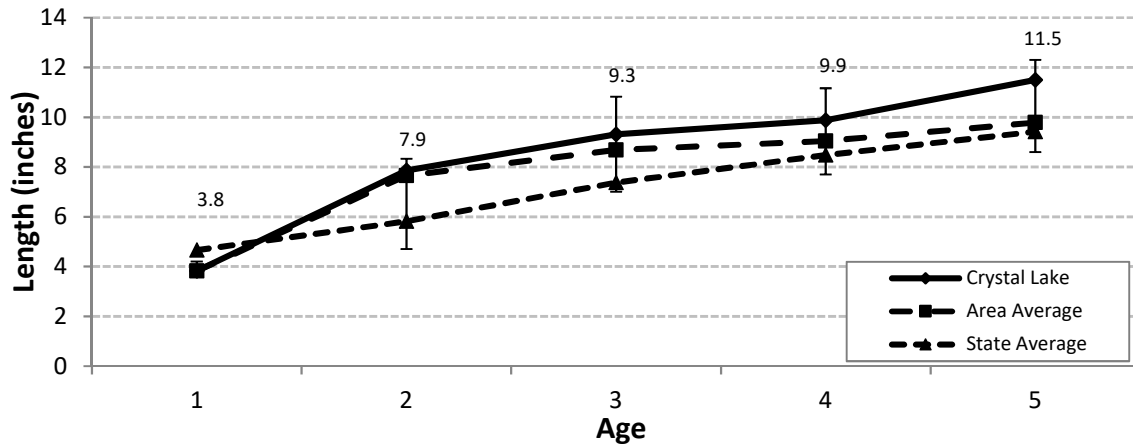Figure 28. Catch curve for largemouth bass collected during the 2015 survey of Crystal Lake, Dane County, Wisconsin.
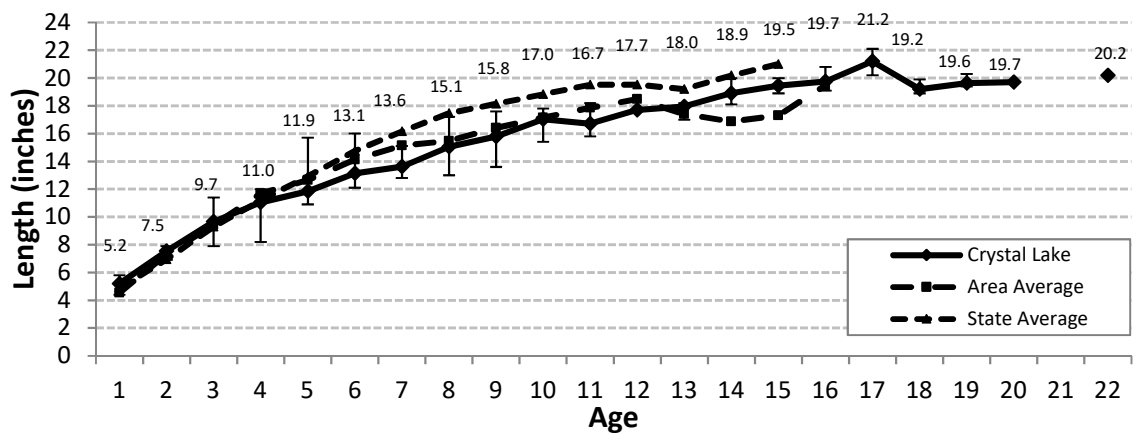
Figure 29. Mean length at age of largemouth bass collected during the 2015 survey of Crystal Lake, Dane County, Wisconsin. Error bars represent minimum and maximum length values for a given age.


Figure 30. Mean length at age of largemouth bass captured during surveys of Crystal Lake, Dane County, Wisconsin in 1999, 2005, and 2015. Values from the 1999 survey are represented in the white boxes with black borders. Values from 2005 are represented in the light gray boxes with black borders. Values from 2015 are represented in the dark gray boxes with no borders.
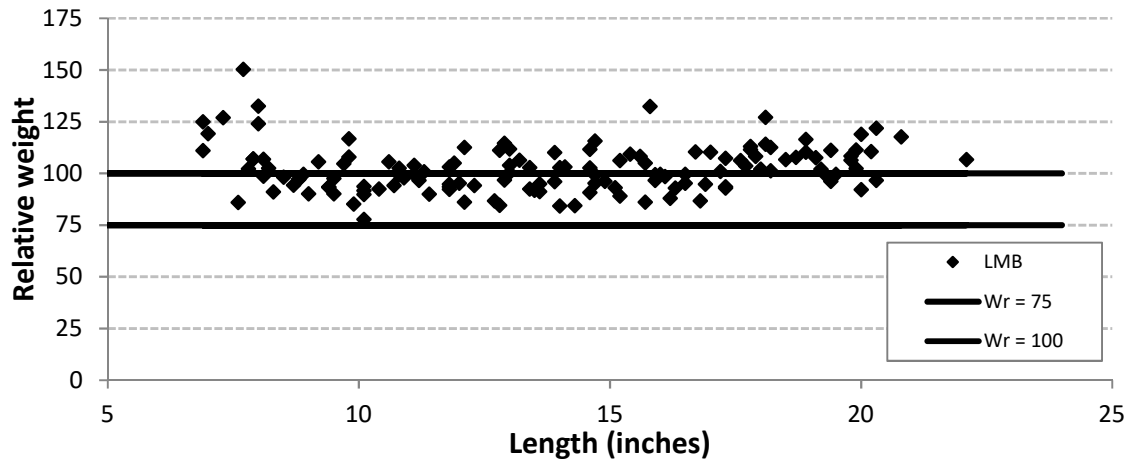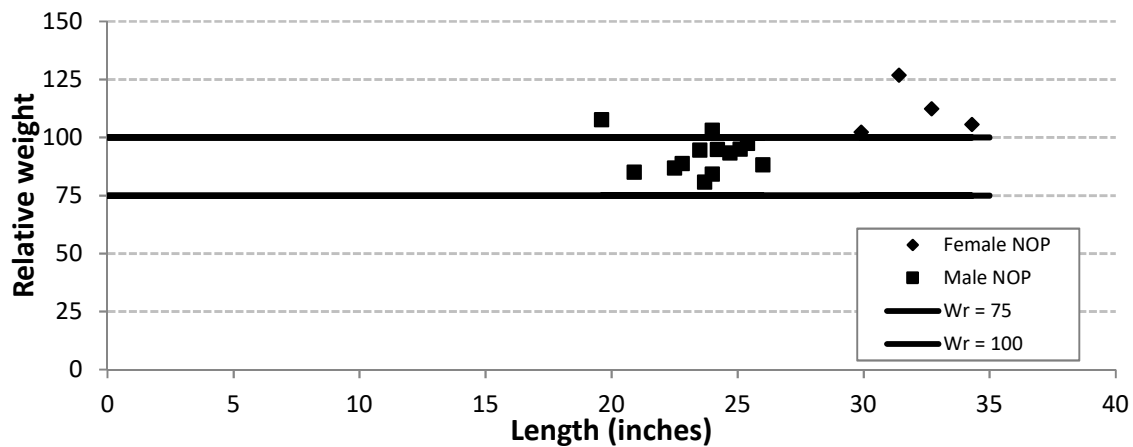
Figure 31. Relative weights of largemouth bass collected during the 2015 survey of Crystal Lake, Dane County, Wisconsin.

Figure 32. Length frequency distribution of white crappies collected using fyke nets during the 2015 survey of Crystal Lake, Dane County, Wisconsin.

Figure 33. Age frequency distribution of white crappies collected using fyke nets during the 2015 survey of Crystal Lake, Dane County, Wisconsin.

Figure 34. Mean length at age of white crappies collected using fyke nets during the 2015 survey of Crystal Lake, Dane County, Wisconsin. Error bars represent minimum and maximum length values for a given age.
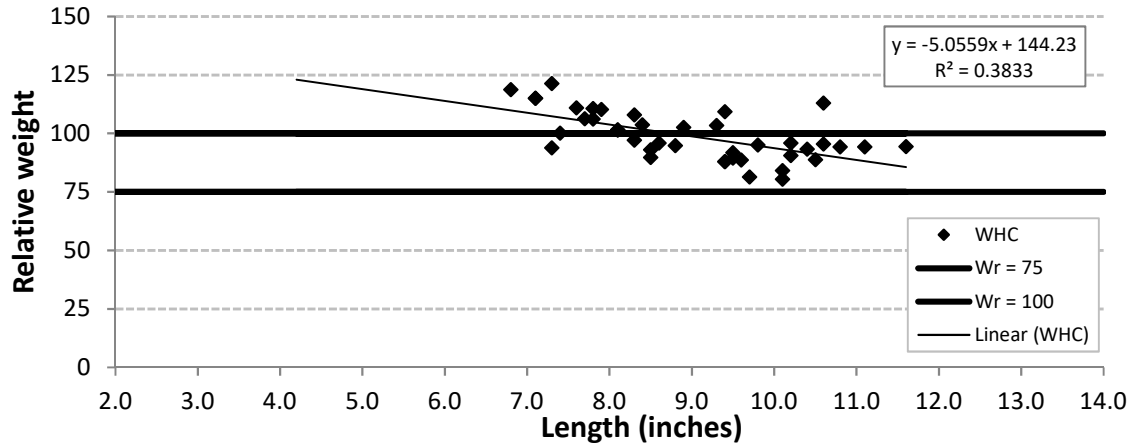
Figure 35. Relative weights of white crappies collected during the 2015 survey of Crystal Lake, Dane County, Wisconsin.

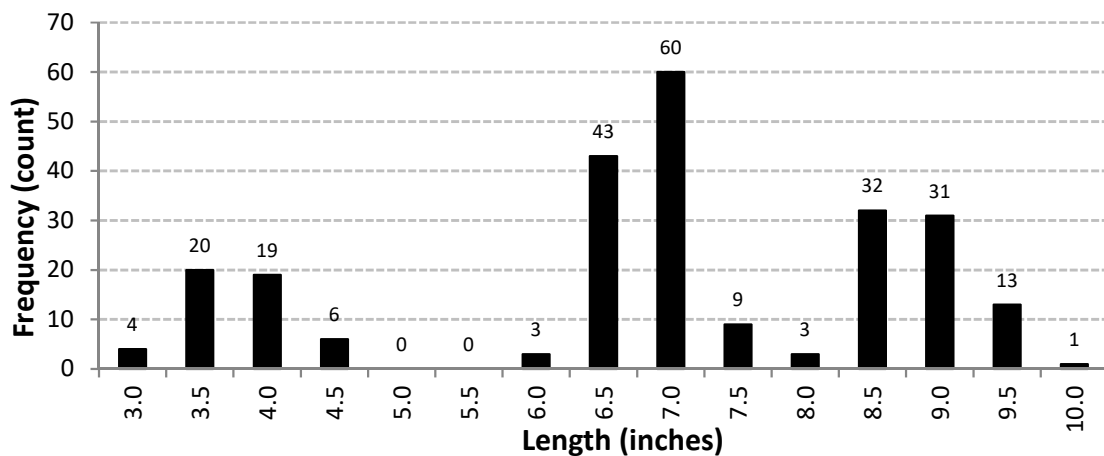Figure 36. Relative weights of northern pike collected during the 2015 survey of Crystal Lake, Dane County, Wisconsin.

Figure 37. Length frequency distribution of yellow bass collected during the 2015 survey of Crystal Lake, Dane County, Wisconsin.
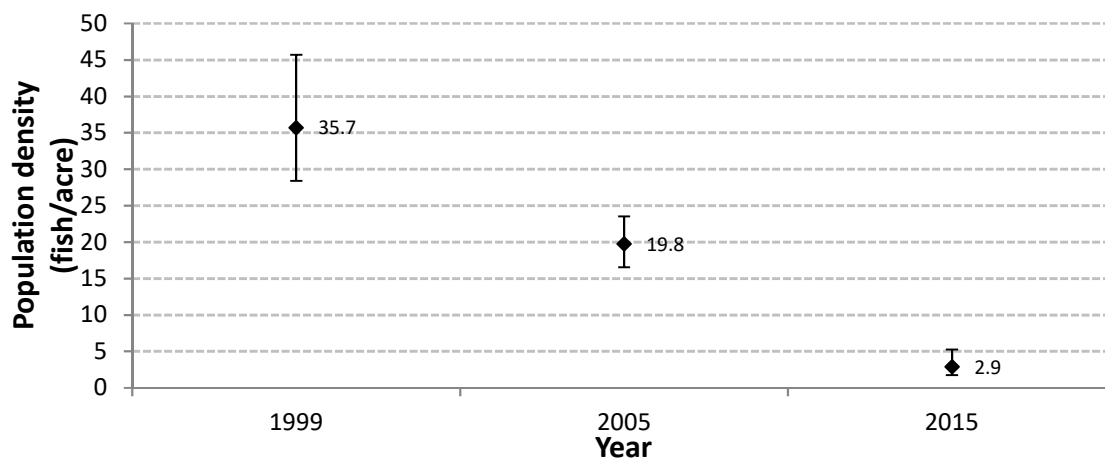
Figure 38. Population density of largemouth bass ≥ 10 inches in Crystal Lake, Dane County, Wisconsin estimated from spring electrofishing surveys in 1999, 2005, and 2015.
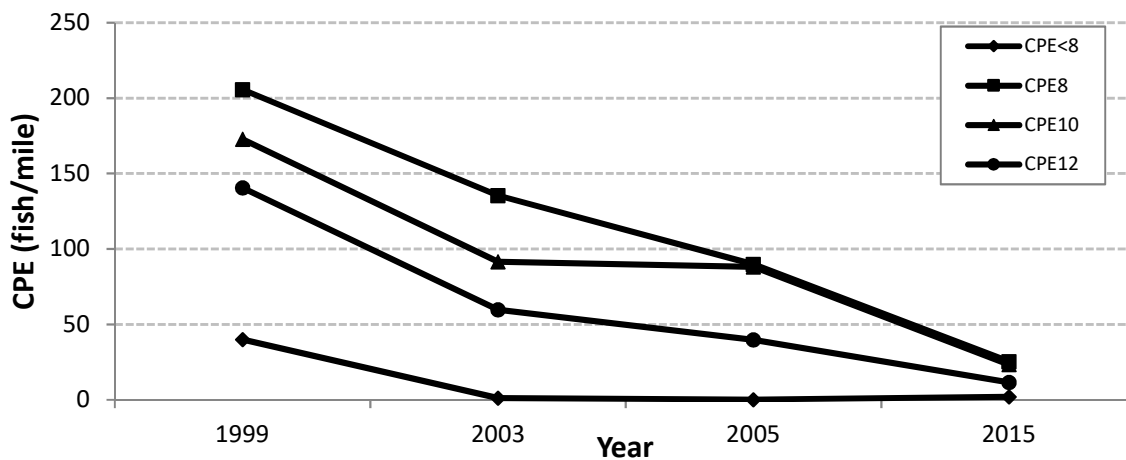

Figure 39. Catch rates of largemouth bass in four May electrofishing surveys of Crystal Lake, Dane County, Wisconsin, 1999-2015.
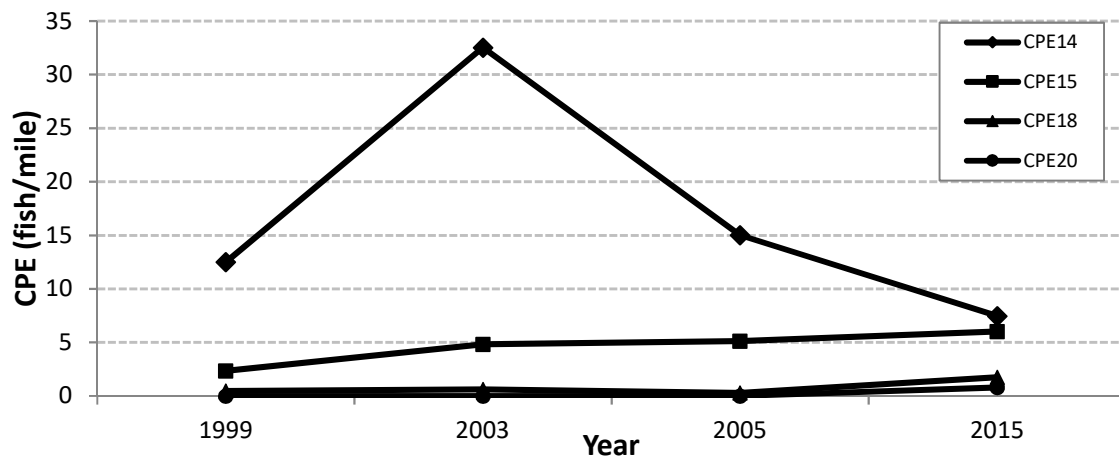
Figure 40. Catch rates of largemouth bass ≥ 14 inches in four May electrofishing surveys of Crystal Lake, Dane County, Wisconsin, 1999-2015.
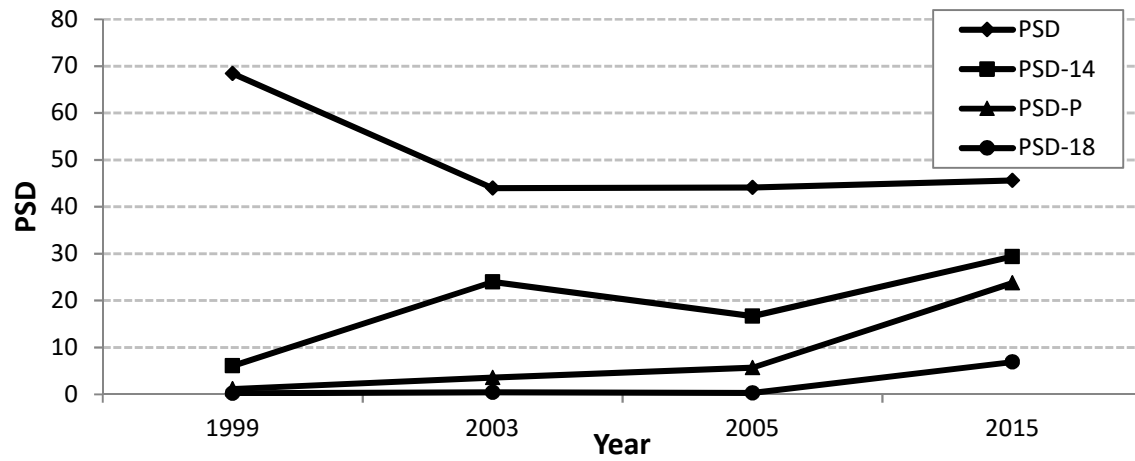

Figure 41. Proportional size distribution (PSD) of largemouth bass in four May electrofishing surveys of Crystal Lake, Dane County, Wisconsin, 1999-2015.